Harlan Lab

OPERATING AND SERVICE MANUAL

HP 410C

ELECTRONIC VOLTMETER

410C

CALIBRATION CONTROL
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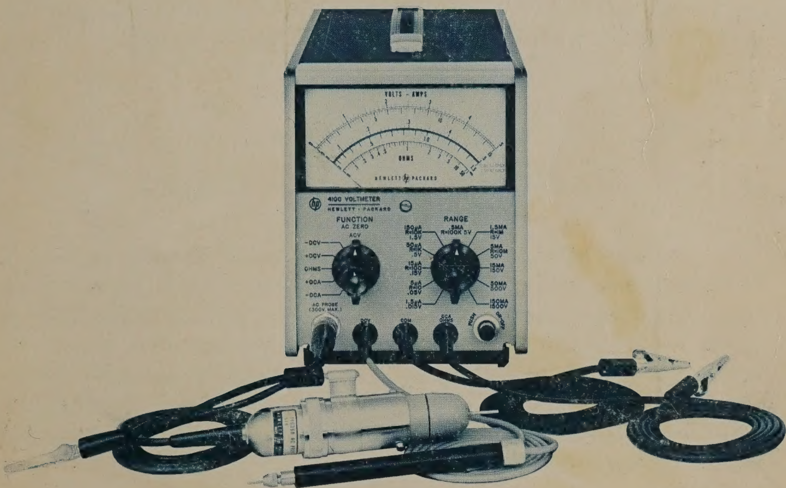

HEWLETT hp PACKARD

HP 410C

HEWLETT hp PACKARD

CERTIFICATION

The Hewlett-Packard Company certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications when it was shipped from the factory. The Hewlett-Packard Company further certifies that its calibration measurements are traceable to the U.S. National Bureau of Standards to the extent allowed by the Bureau's calibration facility.

WARRANTY AND ASSISTANCE

All Hewlett-Packard products are warranted against defects in materials and workmanship. This warranty applies for one year from the date of delivery, or, in the case of certain major components listed in the operating manual, for the specified period. We will repair or replace products which prove to be defective during the warranty period provided they are returned to Hewlett-Packard. No other warranty is expressed or implied. We are not liable for consequential damages.

Service contracts or customer assistance agreements are available for Hewlett-Packard products that require maintenance and repair on-site.

For any assistance, contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual.

OPERATING AND SERVICE MANUAL

-hp- Part No. 00410-90006

MODEL 410C
ELECTRONIC VOLTMETER

Serials Prefixed: 844 -

Appendix C, Manual Backdating
Changes adapts this manual to
Serials Prefixed:
311, 328, 339, 433, 532, 550, and 807

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P.O. Box 301, Loveland, Colorado, 80537 U.S.A.

Printed: Oct 1969

CAUTION

ONE SIDE OF ALMOST ALL POWER DISTRIBUTION SYSTEMS IS GROUNDED. EXTREME CAUTION MUST BE USED IF DIRECT MEASUREMENT OF POWER LINE VOLTAGES IS ATTEMPTED. IF THE GROUND CLIP LEAD IS ACCIDENTALLY CONNECTED TO THE UNGROUNDED SIDE OF THE LINE, SEVERE DAMAGE TO THE 410C IS POSSIBLE BECAUSE OF THE SHORT CIRCUIT CREATED. POWER LINE VOLTAGES CAN BE SAFELY MEASURED BY USING THE PROBE TIP ONLY. CONTACTING THE GROUNDED POWER CONDUCTOR WILL GIVE A READING OF 0 VOLTS WHILE CONTACTING THE UNGROUNDED LEAD WILL GIVE FULL LINE VOLTAGE READING.

MANUAL CHANGES

MODEL 410C

ELECTRONIC VOLTMETER

Manual Serial Prefixed: 844-
-hp- Part No. 00410-90006

► New or Revised Item

Instrument Serial Number	Make Manual Changes
ALL	ERRATA
952- and above	1
982- and above	1, 2
ALL	3

Instrument Serial Number	Make Manual Changes

ERRATA

Page 6-4, Replaceable Parts:
Change A7CR7 to -hp- Part No. 1902-0681.

CHANGE 1

This change effective on all instruments with Serial No. Prefix 952- and above except H60-410C instruments.

Page 6-5, Replaceable Parts:
Change F1 to -hp- Part No. 2110-0201.
Change J3 to -hp- Part No. 1251-2357.
Change S1 to -hp- Part No. 3101-1248.
Change S2 to -hp- Part No. 3101-1234.
Change W1 to -hp- Part No. 8120-1348.

Page 6-6, Replaceable Parts:
Change Panel: front to Part No. 00410-00201.
Change Panel: rear to Part No. 00410-00202.

The above changes were made to conform to new I.E.C. standards (No. 66).

CHANGE 2

Beginning with Serial No. 982-12404, rear panel markings were changed to conform to new I.E.C. standards (No. 66), except on H60-410C instruments.

►

CHANGE 3

Page 6-4. Replaceable Parts:
Change A7CR8 to 1902-3119, 6.49 V.

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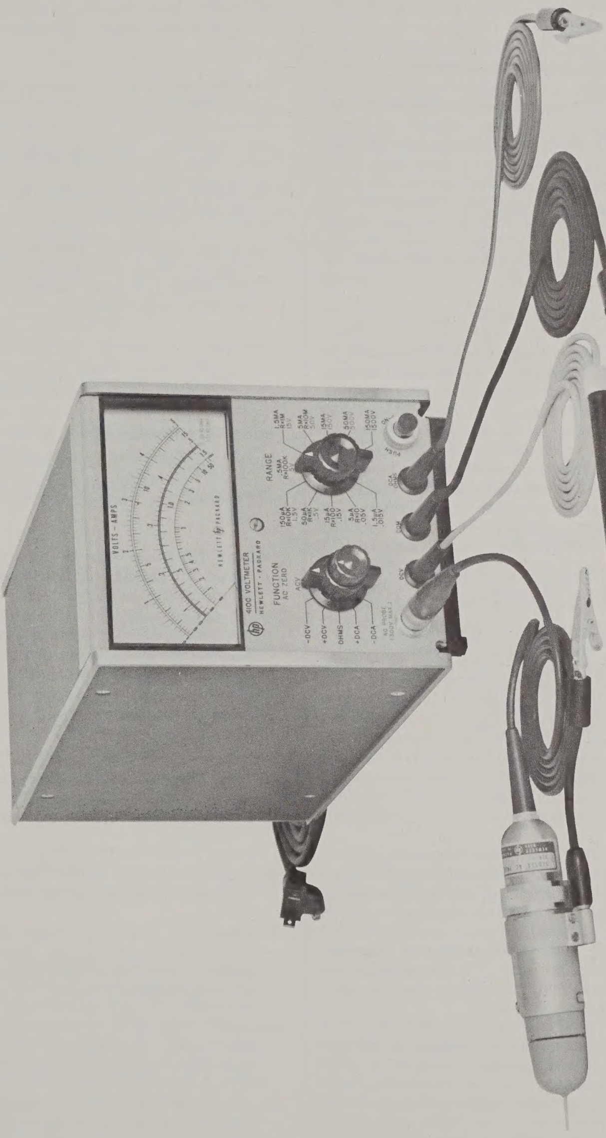


Figure 1-1. The hp Model 410C Electronic Voltmeter

Table 1-1. Specifications

DC VOLTMETER

Voltage Ranges: ±15 mv to ±1500 v full scale in 15, 50 sequence (11 ranges).

Accuracy: ±2% of full scale on any range.

Input Resistance: 100 megohms ±1% on 500 mv range and above.
10 megohms ±3% on 15 mv, 50 mv, and 150 mv ranges.

DC AMMETER

Current Ranges: ±1.5 μa to ±150 ma full scale in 1.5, 5 sequence (11 ranges).

Accuracy: ±3% of full scale on any range.

Input Resistance: Decreasing from 9 K ohms on 1.5 μa scale to approximately 0.3 Ω on the 150 ma scale.

Special Current Ranges: ±1.5, ±5, and ±15 nanoamps may be measured on the 15, 50, and 150 millivolt ranges using the voltmeter probe, with ±5% accuracy and 10 megohm input resistance.

OHMMETER

Resistance Range: Resistance from 10 ohms to 10 megohm center scale (7 ranges).

Accuracy: Zero to midscale: ±5% of reading or ±2% of midscale, whichever is greater.
±7% from midscale to scale value of 2.
±8% from scale value of 2 to 3.
±9% from scale value of 3 to 5.
±10% from scale value of 5 to 10.

AMPLIFIER

Voltage Gain: 100 maximum.

AC Rejection: 3 db at 1/2 cps; approximately 66 db at 50 cps and higher frequencies for signals less than 1600 v peak or 30 times full scale, whichever is smaller.

Isolation: Impedance between common and chassis is >10 meg in parallel with 0.1 μf. Common may be floated up to 400 v dc above chassis for dc and resistance measurements.

Output: Proportional to meter indication; 1.5 v dc at full scale, maximum current, 1 ma.

Output Impedance: Less than 3 ohms at dc.

Noise: Less than 0.5% of full scale on any range (p-p).

AMPLIFIER (Cont'd)

DC Drift: Less than 0.5% of full scale/year at constant temperature. Less than 0.02% of full scale /°C.

Overload Recovery: Recover from 100:1 overload in <3 sec.

AC VOLTMETER

Ranges: 0.5 v full scale to 300 v in 0.5, 1.5, 5 sequence (7 ranges).

Accuracy: ±3% of full scale at 400 Hz for sinusoidal voltages from 0.5 to 300 v rms. The AC Probe responds to the positive peak-above-average value of the applied signal.

Frequency Response: ±2% from 100 Hz to 50 MHz (400 Hz ref.), 0% to -4% from 50 MHz to 100 MHz ±10% from 20 Hz to 100 Hz and from 100 MHz to 700 MHz.

Frequency Range: 20 Hz to 700 MHz.

Input Impedance: Input capacity 1.5 pf, input resistance >10 megohms at low frequencies. At high frequencies impedance drops off due to dielectric loss.

Safety: The probe body is grounded to chassis at all times for safety. All ac measurements are referenced to chassis ground.

Meter: Individually calibrated taut band meter. Responds to positive peak-above-average. Calibrated in rms volts for sine wave input.

GENERAL

Maximum Input: (see Overload Recovery)
DC: 100 v on 15, 50, and 150 mv ranges; 500 v on 0.5 to 15 v ranges; 1600 v on higher ranges.
AC: 100 times full scale or 450 v peak, whichever is less.

Power: 115 or 230 v ±10%. 50 to 400 Hz, 13 watts (20 watts with 11036A AC Probe).

Dimensions: 6-1/2 in. high (16.5 cm); 5-1/8 in. wide (13.01 cm); 11 in. deep (27.9 cm) behind panel. Fits 5060-0797 Rack Adapter and 1050 series combining cases.

Weight:
Net: 8 lbs. (4.0 kg).
Shipping: approximately 14 lbs. (6.35 kg).

Accessories Furnished: Detachable power cord, NEMA plug; hp Model 11036A AC Probe.

Option 02: hp Model 410C less AC Probe.

SECTION I
GENERAL INFORMATION

1-1. DESCRIPTION.

1-2. The Hewlett-Packard Model 410C Electronic Voltmeter can be used to measure dc voltage and dc current; ac voltage and resistance. Positive and negative dc voltages from 15 millivolts to 1500 volts full scale and positive and negative dc currents from 1.5 microamperes to 150 milliamperes can be measured full scale. Resistance from 10 ohms to 10 megohms mid-scale can be measured with an accuracy of ±5%; resistance from 0.2 ohms to 500 megohms can be measured with reduced accuracy. The Model 410C Electronic Voltmeter is shown in Figure 1-1; the specifications are given in Table 1-1.

1-3. With the Model 11036A detachable AC Probe, the Voltmeter can be used to measure AC voltage from 20 Hz to 700 MHz. From 20 Hz to 100 MHz, AC voltage from 0.5 to 300 volts can be measured; from 100 MHz to 700 MHz, refer to Figure 3-5 for maximum AC voltage that can be applied to the AC Probe. For additional information on the AC Probe, refer to Paragraph 1-8.

1-4. INSTRUMENT IDENTIFICATION.

1-5. Hewlett-Packard uses a two section, eight-digit serial number (000-00000). The serial number is on a plate attached to the rear panel of the instrument. If the first three digits of the serial number on your instrument do not agree with those on the title page of this manual, Appendix C, Backdating Changes will define differences between your instrument and the Model 410C described in this manual.

1-6. ACCESSORIES AVAILABLE.

1-7. Accessories are available that extend the AC and DC measuring capabilities of the Voltmeter. A description of these accessories and their specifications is given below.

1-8. MODEL 11036A AC PROBE. This accessory, when used with the Model 410C, permits AC voltage measurements from 0.5 volts rms to 300 volts rms, full scale over a frequency range of 20 Hz to 700 MHz. Reference calibration accuracy at 400 Hz (sinusoidal) is ±3% of full scale. Frequency response is ±10% from 20 Hz to 700 MHz, with indications obtainable to 3000 MHz. Frequency response at 100 MHz is within ±2%. The Model 11036A responds to the positive-peak-above-average value of the signal applied. The Model 410C is calibrated to read in RMS volts, for sine wave inputs.

1-9. MODEL 11039A CAPACITIVE VOLTAGE DIVIDER. This accessory (formerly the Model 452A) extends the AC voltage range of the Model 410C to 25 kv. The divider permits measurements of extremely high AC voltage such as encountered in dielectric heating equipment, etc., over a frequency range of 25 Hz to 20 MHz. A fixed gap is provided so that breakdown will occur if the applied voltage exceeds 28 kv at low frequencies. Voltage division is 1000:1, ±3%, and input capacity is 15 picofarads. A Model 11018A Adapter is also required to connect the Model 11036A AC Probe to the shielded banana plug fitting of the divider.

1-10. MODEL 11040A CAPACITY DIVIDER. This accessory (formerly the Model 453A) extends the AC voltage range of the Voltmeter to 2000 volts RMS. The divider is for use at frequencies above 10 kHz. Voltage division is 100:1, ±1%, and input capacity is approximately 2 picofarads.

1-11. MODEL 11042A PROBE T CONNECTOR. This accessory (formerly the Model 455A) is used for connecting the Model 11036A Probe across a 50-ohm transmission line using type N connectors. The T-joint is such that connection of the probe into a transmission line will not cause a standing wave ratio greater than 1.1 at 500 MHz and 1.2 at 1000 MHz. With this device, measurement of power traveling through a transmission line may be made with reasonable accuracy to 1000 MHz. The usual precautions must be taken to provide accurate impedance matching and the elimination of standing waves along the line through which power is floating. By using a dummy load at the receiving end of this T-joint, power output of various devices can be measured. In many applications power going into a real load, such as an antenna, can be conveniently measured up to 1000 MHz with good accuracy.

1-12. MODEL 11043A TYPE N CONNECTOR. This accessory (formerly the Model 458A) allows the AC Probe to be connected to a 50-ohm coaxial line. The connector uses a male type N connector and a receptacle for receiving the probe. Terminating resistor is not included.

1-13. MODEL 11045A DC DIVIDER. This accessory extends the maximum DC voltage range of the Model 410C to 30 kv. Voltage division is 100:1, ±5%, and input resistance is 9900 megohms. When used with the Model 410C, input resistance is 10,000 megohms. This probe offers maximum safety and convenience for measuring high voltages such as in television equipment, etc. The maximum current drain is 2.5 microamperes.

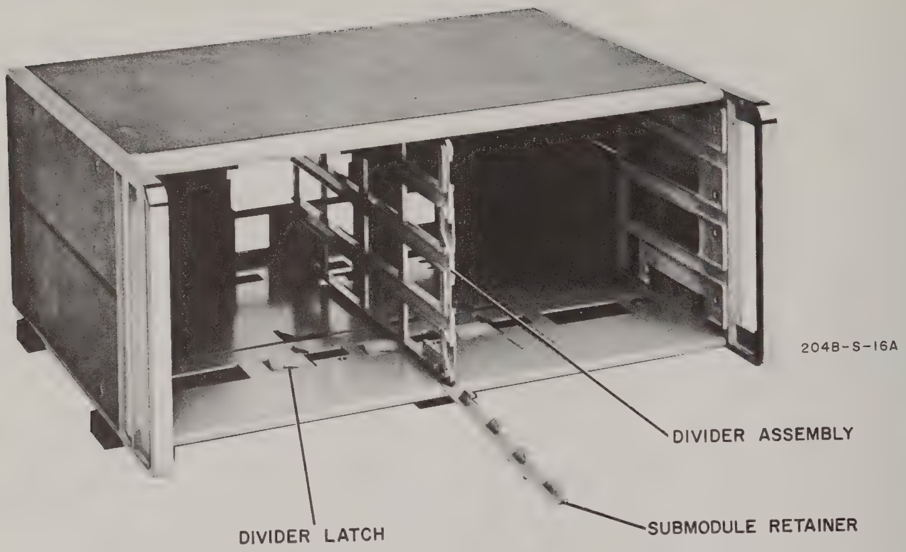


Figure 2-1. The Combining Case

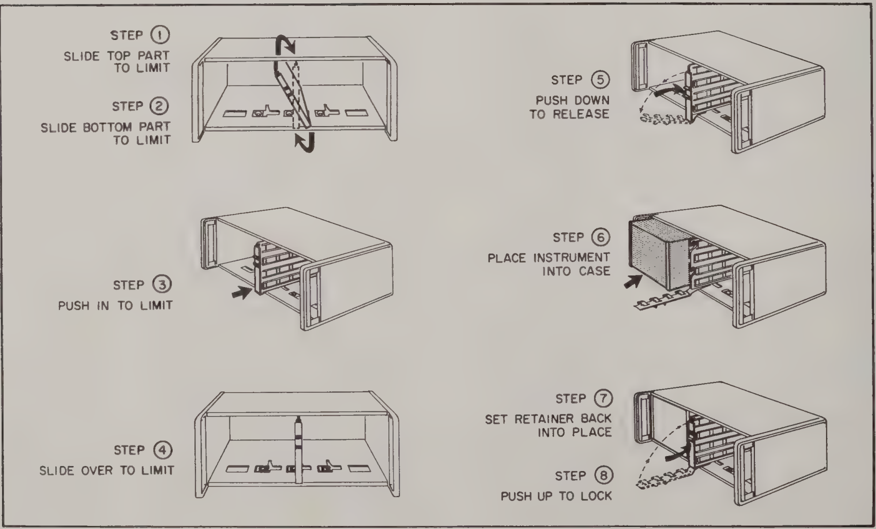


Figure 2-2. Steps to Place Instrument in Combining Case

SECTION II
INSTALLATION

2-1. INSPECTION.

2-2. This instrument was carefully inspected both mechanically and electrically, before shipment. It should be physically free of mars or scratches and in perfect electrical order upon receipt. To confirm this, the instrument should be inspected for physical damage in transit. Also, check for supplied accessories, and test the electrical performance of the instrument using the procedure outlined in Paragraph 5-5, Performance Checks. If there is damage or deficiency, see the warranty on the inside front cover of this manual.

2-3. INSTALLATION.

2-4. The ⓗⓟ Model 410C is transistorized except for one vacuum tube and requires no special cooling. However, the instrument should not be operated where the ambient temperature exceeds 55° C (140° F).

2-5. RACK MOUNTING.

2-6. The Model 410C is a submodular unit designed for bench use. However, when used in combination with other submodular units, it can be bench and/or rack mounted. The ⓗⓟ Combining Cases and Adapter Frame are designed specifically for this purpose.

2-7. MODELS 1051A AND 1052A COMBINING CASES. The Combining Cases are full-module units which accept various combinations of submodular units. Being a full width unit, it can either be bench or rack mounted. An illustration of the Combining Case is shown in Figure 2-1. Instructions for installing the Model 410C are shown in Figure 2-2.

2-8. RACK ADAPTER FRAME (ⓗⓟ Part No. 5060-0797). The adapter frame is a rack mounting frame that accepts various combinations of submodular units. It can be rack mounted only. An illustration of the adapter frame is given in Figure 2-3. Instructions are given below.

a. Place the adapter frame on edge of bench as shown in step 1, Figure 2-4.

b. Stack the submodular units in the frame as shown in step 2, Figure 2-4. Place the spacer clamps between instruments as shown in step 3, Figure 2-4.

c. Place spacer clamps on the two end instruments (see step 4, Figure 2-4) and push the combination into the frame.

d. Insert screws on either side of frame, and tighten until submodular instruments are tight in the frame.

e. The complete assembly is ready for rack mounting.

2-9. THREE-CONDUCTOR POWER CABLE.

2-10. To protect operating personnel, the National Electrical Manufacturers' Association (NEMA) recommends that the instrument panel and cabinet be grounded. All Hewlett-Packard instruments are equipped with a three-conductor power cable which grounds the instrument when plugged into an appropriate receptacle.

2-11. To preserve the protection feature when operating the instrument from a two-contact outlet, use three-prong to two-prong adapter and connect the green pigtail on the adapter to ground.

2-12. PRIMARY POWER REQUIREMENTS.

2-13. The Model 410C can be operated from either 115 or 230 volts, 50 to 400 Hz. The instrument can be easily converted from 115- to 230- volt operation. The LINE VOLTAGE switch, S4 a two-position slide switch located at the rear of the instrument, selects the mode of AC operation. The line voltage from which the instrument is set to operate appears on the slider of the switch. A 0.25-ampere, slo-blo fuse is used for both 115- and 230-volt operation. If the Model 410C is operated at any frequency other than 60 Hz, perform chopper frequency adjust (Paragraph 5-31).

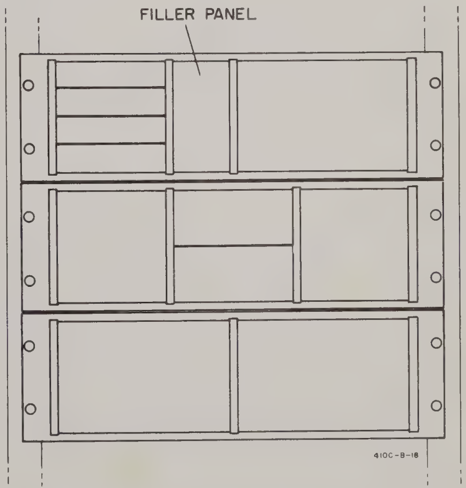


Figure 2-3. Adapter Frame Instrument Combination

CAUTION

DO NOT CHANGE THE SETTING OF THE LINE VOLTAGE SWITCH WHEN THE VOLTMETER IS OPERATING.

2-14. REPACKAGING FOR SHIPMENT.

2-15. The following paragraphs contain a general guide for repackaging of the instrument for shipment. Refer to Paragraph 2-16 if the original container is to be used; 2-17 if it is not. If you have any questions, contact your local ⓗⓟ Sales and Service Office. (See Appendix B for office locations.)

NOTE

If the instrument is to be shipped to Hewlett-Packard for service or repair, attach a tag to the instrument identifying the owner and indicate the service or repair to be performed; include the model number and full serial number of the instrument. In any correspondence, identify the instrument by model number, serial number and serial number prefix.

2-16. If the original container is to be used, proceed as follows:

a. Place instrument in original container if available. If original container is not available, one can be purchased from your nearest ⓗⓟ Sales and Service Office.

b. Ensure that container is well sealed with strong tape or metal bands.

2-17. If original container is not to be used, proceed as follows:

a. Wrap instrument in heavy paper or plastic before placing in an inner container.

b. Place packing material around all sides of instrument and protect panel face with cardboard strips.

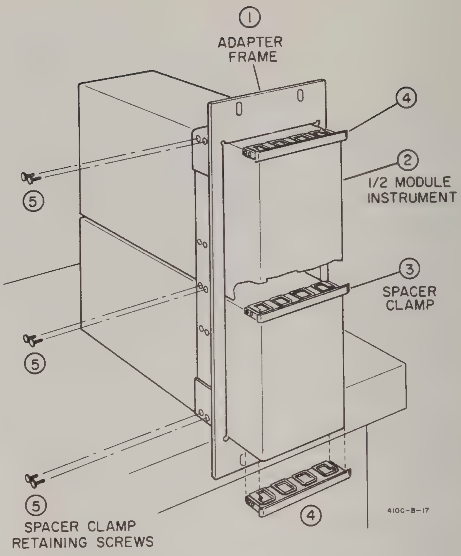


Figure 2-4. Two Half Modules in Rack Adapter

c. Place instrument and inner container in a heavy carton or wooden box and seal with strong tape or metal bands.

d. Mark shipping container with "DELICATE INSTRUMENT", "FRAGILE", etc.

SECTION III
OPERATION

3-1. INTRODUCTION.

3-2. The Model 410C is used to measure AC and DC voltage, DC current, and resistance. All measurement inputs are located on the front panel; a DC output connector is located on the rear panel. Front panel controls and indicators are color coded. DC voltage, DC current and resistance knobs and indicators are in black; AC voltage controls and indicators are in red.

3-3. ADJUSTMENT OF MECHANICAL ZERO.

3-4. The procedure for adjustment of mechanical zero is given in Section V.

3-5. FRONT AND REAR PANEL DESCRIPTION.

3-6. Figure 3-1 describes the function of all front and rear panel controls, connectors and indicators. The description of each control, connector and indicator is keyed to a drawing which accompanies the figure.

3-7. OPERATING PROCEDURES.

3-8. There are five operating procedures: DC Voltage Measurements, Figure 3-2; DC Current Measurements, Figure 3-3; AC Voltage Measurements, Figure 3-4; Resistance Measurements, Figure 3-7; and Measuring DC Current in Nano-amperes, Figure 3-8.

Note

> Ageing of the neon lamps in the chopper assembly can cause a change in chopper frequency which produces a slight oscillatory movement of meter pointer. If this oscillatory movement is observed, rotate Osc Freq Adj A3R5 (see Paragraph 5-31) in the ccw direction until oscillation of pointer stops.

3-9. DC VOLTAGE MEASUREMENTS (Figure 3-2).

3-10. The Model 410C is normally floating; however a shorting bar can be connected at the DC AMPLIFIER OUTPUT connector on the rear panel. When the instrument is floating, the COM Lead should not be connected to voltages greater than 400 VDC.

3-11. DC CURRENT MEASUREMENTS (Figure 3-3).

3-12. General instructions for the measurement of DC current are the same as those given for DC voltage measurements, Paragraph 3-9.

3-13. AC VOLTAGE MEASUREMENTS (Figure 3-4).

CAUTION

ONE SIDE OF ALMOST ALL POWER DISTRIBUTION SYSTEMS IS GROUNDED. EXTREME CAUTION MUST BE USED IF DIRECT MEASUREMENT OF POWER LINE VOLTAGES IS ATTEMPTED. IF THE GROUND CLIP LEAD IS ACCIDENTALLY CONNECTED TO THE UNGROUNDED SIDE OF THE LINE SEVERE DAMAGE TO THE 410C IS POSSIBLE BECAUSE OF THE SHORT CIRCUIT CREATED. POWER LINE VOLTAGES CAN BE SAFELY MEASURED BY USING THE PROBE TIP ONLY. CONTACTING THE GROUNDED POWER CONDUCTOR WILL GIVE A READING OF 0 VOLTS WHILE CONTACTING THE UNGROUNDED LEAD WILL GIVE FULL VOLTAGE READING.

3-14. Although the Model 410C indicates a full scale AC range of 500 volts, the optional Model 11036A AC Probe should not be connected to AC voltages in excess of 300 volts RMS. AC voltage referenced to a DC voltage may be measured, but the AC Probe clip (alligator type) must be connected to the ground (⏚) of the circuit under test.

CAUTION

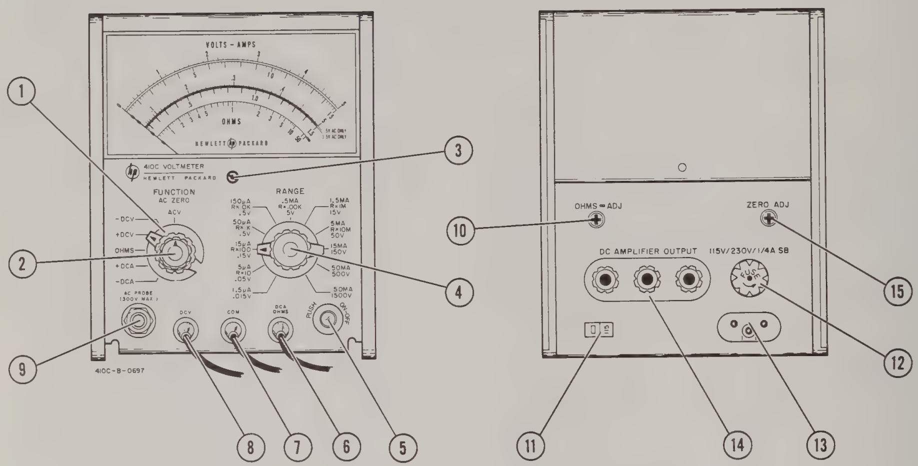
WHEN MEASURING AC REFERENCED TO DC, THE PEAK AC VOLTAGE PLUS DC VOLTAGE CONNECTED TO THE PROBE MUST NOT EXCEED 420 VOLTS.

3-15. PRECAUTIONS WHEN MEASURING AC VOLTAGE.

3-16. Special considerations must be kept in mind when making AC voltage measurements. These considerations are discussed in the following paragraphs.

3-17. GENERAL CONSIDERATION OF COMPLEX WAVEFORMS. Waveforms containing appreciable harmonics or spurious voltages will introduce error in the meter indication since the meter has been calibrated to read RMS values of true sine waves while the Model 11036A Probe is a peak-above-average responding device. The magnitude of error that may be expected when harmonics are present on the measured waveform is indicated in Table 3-1.

3-18. VOLTAGE MEASUREMENTS AT FREQUENCIES BELOW 50 CYCLES/SECOND. Voltage measurements at frequencies as low as 20 cycles per



(1) FUNCTION SELECTOR: This control is used for selecting type of measurement to be made. They are: ±DC Voltage, ±DC Current, AC Voltage, and resistance measurements.

(2) AC ZERO: This control provides adjustment for zero-setting the meter before making AC voltage measurements.

(3) MECHANICAL ZERO ADJUST: This adjustment mechanically zero-sets the meter prior to turning on Voltmeter.

(4) RANGE: This control selects the full scale meter range.

(5) AC POWER SWITCH: This pushbutton-lamp combination, when depressed, turns the instrument power on or off. The pushbutton glows when the Voltmeter power is on.

(6) DCA-OHMS: This lead is used in conjunction with the COM Lead to measure DC current or ohms. The FUNCTION SELECTOR determines which measurement is made.

(7) COM: This lead is used with the input leads for DC voltage current, DC voltage, and resistance measurements. The COM Lead is normally floating; however, a shorting bar can be connected from the floating ground terminal to the chassis ground terminal on the DC AMPLIFIER OUTPUT connector. If a shorting bar is not used, the COM Lead is floating except when the FUNCTION SELECTOR is set to ACV.

(8) DCV: This lead is used in conjunction with the COM Lead to measure ±DC voltage.

(9) AC PROBE (300V MAX): Receptacle for telephone-type plug of Model 11036A AC Probe. With probe connected, the Voltmeter may be used to make AC voltage measurements.

(10) ∞ ADJUST: This control is used to set meter pointer to ∞ before resistance measurements are made. Only periodic adjustment of this screwdriver adjustment is necessary.

(11) LINE VOLTAGE: This two-position slide switch sets the instrument to accept either 115 or 230 volt AC primary power.

(12) FUSEHOLDER: The fuseholder contains a 0.25 ampere slow-blow fuse for both 115 vac and 230 vac modes of operation.

(13) AC POWER CONNECTOR: Accepts power cable supplied with the instrument.

(14) DC AMPLIFIER OUTPUT: Provides DC voltage output proportional to meter indication for driving external recorder. 1.5 volts DC output for full scale meter deflection.

(15) ZERO ADJUST: This control is used to set meter pointer to zero when calibrating for DC and resistance measurements.

Figure 3-1. Front and Rear Panel Controls

second may be made without loss of accuracy by removing the plastic nose on the Model 11036A and using in its place a 0.25 microfarad blocking capacitor in series with the exposed contact of the probe.

CAUTION

THE GRAY INSULATING MATERIAL AROUND THE AC PROBE IS POLYSTYRENE, A LOW-MELTING POINT MATERIAL. IT IS NOT POSSIBLE TO SOLDER TO THE CONTACT WHICH IS EXPOSED WITH THE PROBE NOSE REMOVED WITHOUT DESTROYING THE POLYSTYRENE.

Table 3-1. Possible Error When Measuring Voltage of Complex Waveforms

% Harmonic	True RMS Value	Voltmeter Indication
0	100	100
10% 2nd	100.5	90 to 110
20% 2nd	102	80 to 120
50% 2nd	112	75 to 150
10% 3rd	100.5	90 to 110
20% 3rd	102	87 to 120
50% 3rd	112	108 to 150

3-19. VOLTAGE MEASUREMENT AT HIGH FREQUENCIES. At frequencies above 100 megahertz the distance between the point of voltage measurement and anode of the probe diode must be made as short as possible. If feasible, substitute a small disc type capacitor of approximately 50 picofarads for the removable tip on the probe. Solder one terminal of the button capacitor to the measurement point in the circuit and not to the probe contact. The probe contact (with tip removed) can then contact the other terminal of the capacitor for the measurement.

3-20. At frequencies above 100 megahertz considerable voltage may be built up across ground leads and along various part of a grounding plane. Consequently, to avoid erroneous readings when measuring medium and high frequency circuits, use the ground clip lead on the shell of the probe to connect the circuit ground. In some cases at the higher frequencies it may be necessary to shorten the grounding lead on the probe.

3-21. For all measurements at higher frequencies, hold the molded nose of the probe as far from the external ground plane or from object at ground potential as can conveniently be done. Under typical conditions, this practice will keep the input capacitance several tenths of a picofarad lower than otherwise.

3-22. For measurements above approximately 250 megahertz it is almost mandatory that measurements be made on voltages which are confined to coaxial transmission line circuits. For applications of this type, the Model 11036A Probe is particularly suitable because the physical configuration of the diode and probe is that of a concentric line, and with a few precautions it can be connected to typical coaxial transmission line circuits with little difficulty.

3-23. To connect the probe into an existing coaxial transmission line, cut the line away so the center conductor of the line is exposed through a hole large enough to clear the body of the probe. The nose of the probe should be removed for this type of measurement. Connect one terminal of a button-type capacitor of approximately 50 picofarads to the center conductor of the coaxial line so that the other terminal of the capacitor will contact the anode connection of the probe. A close-fitting metal shield or bushing should be arranged to ground the outer cylinder of the probe to the outer conductor of the transmission line. This type of connection is likely to cause some increase in the standing wave ratio of the line at higher frequencies. The Model 11042A Probe T Connector is designed to do this job with SWR or less than 1.1 at 500 MHz (see Paragraph 1-11).

3-24. EFFECT OF PARASITICS ON VOLTAGE READINGS. At frequencies above 500 megahertz leads or portions of circuits often resonate at frequencies two, three, or four times the fundamental of the voltage being measured. These harmonics may cause serious errors in the meter reading. Owning to the resonant rise in the probe circuit at frequencies above 1000 megacycles, the meter may be more sensitive to the harmonics than to the fundamental. To make dependable measurements at these frequencies, the circuits being measured must be free of all parasitics.

3-25. EFFECT OF DC PRESENT WITH AC SIGNAL. When measuring an AC signal at a point where there is a high DC potential, such as at the plate of a vacuum tube, the high DC potential may cause small leakage current through the blocking capacitor in the tip of the Model 11036A AC Probe. When the AC signal under measurement is small, the error introduced into the reading can be significant. To avoid leakage, an additional capacitor with a dielectric such as mylar or polystyrene which has high resistance to leakage is required. (Use 5 picofarads or higher, and insert the capacitor between the point of measurement and the probe tip.)

3-26. PULSE MEASUREMENTS.

3-27. POSITIVE PULSES. The Model 11036A AC Probe is peak-above-average responding and clamps the positive peak value of the applied voltage. This permits the probe to be used to measure the positive-voltage amplitude of a pulse, provided the reading obtained is multiplied by a factor determined from the following expression:

$$1.4\left(1 + \frac{t_1}{t_2} + \frac{K}{PRF}\right)$$

t_1 is the duration of the positive portion of the voltage in microseconds.

t_2 is the duration of the negative portion of the voltage in microseconds.

K is a factor determined from the expression R_o/t_1 and the graph shown in Figure 3-6, where R_o is the source impedance of the pulse generator in kilohms, and t_1 is the duration of the positive portion of the pulse in microseconds.

PRF is the pulse repetition frequency in pulses per second (pps).

Suppose, for example:

t_1 = 10 microseconds

t_2 = 990 microseconds

K = 0.55

PRF = 1000 pps

To find K, assuming R_o = 2 kilohms and t_1 = 10 microseconds: R_o/t_1 = 2/10° = 0.2. Location 0.2 on the X axis of the graph shown as Figure 3-6, and reading K where X and Y axes intersect the unmarked curve. If the ratio of R_o/t_1 were greater than 1, multiply the X and Y axes by 10, and use the curve marked "R_o/t_1 and K each X10".

Solving the expression for the multiplying factor,

$$1.4 \quad 1 + \left(\frac{10}{990} + \frac{0.55}{1000}\right) =$$

$$1.4\ (1 + 0.01 + 0.00055) =$$

$$1.4\ (1.01055) =$$

$$1.41477$$

3-28. NEGATIVE PULSES.

3-29. In the case of a 10 microsecond negative pulse (t_2) and a pulse repetition frequency (PRF) of 1000 pps, t_1 would be 990 microseconds. Thus T_o/t_1 would be approximately 0, and from the graph it is seen that K is approximately 0. The expression would then reduce to

$$1.4\ \left(1 + \frac{990}{10}\right)$$

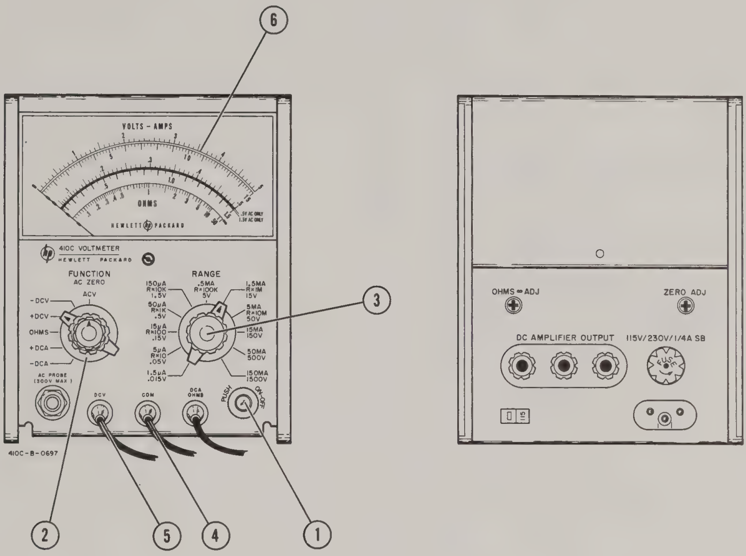
3-30. It can be seen that in the case of negative pulses of short duration much smaller readings will be obtained for an equivalent positive pulse. As a result, large multiplying factors must be used and unless the pulse voltage is large, these measurements may be impractical.

3-31. MEASURING RESISTANCE (Figure 3-7).

3-32. Before making resistance measurements, power must be removed from the circuit to be tested. Also, make sure capacitors are discharged to eliminate any residual voltage.

3-33. MEASURING DC NANO-AMPERE CURRENT (Figure 3-8).

3-34. The Model 410C can be used to measure nano-ampere leakage current in transistors and diodes. The three most sensitive DC voltage measurement ranges are used to measure DC nano-ampere currents.



(1) Depress the AC power switch (neon - switch combination).

(2) Set FUNCTION SELECTOR to polarity desired (+DCV or -DCV).

(3) Set RANGE to desired voltage position.

(4) Connect COM Lead to the ground of circuit under test.

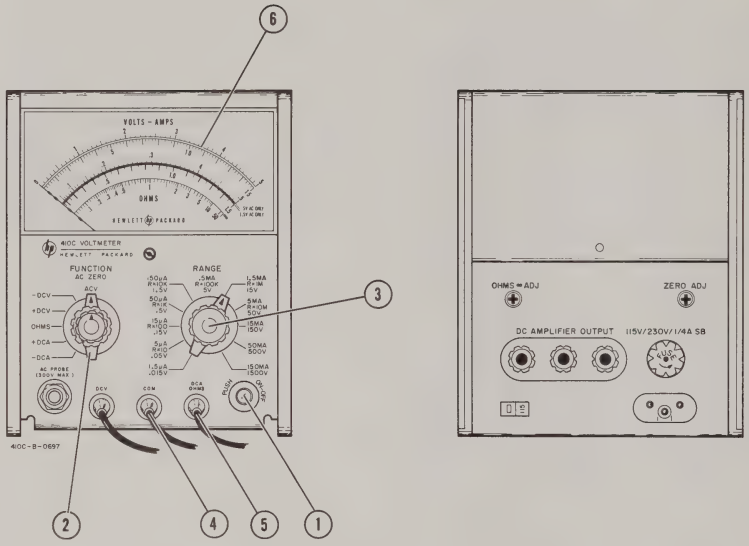
(5) Touch DCV probe to test point.

(6) Read voltage on the VOLTS-AMPS scale.

Note

Aging of the neon lamps in the chopper assembly can cause a change in chopper frequency which produces a low amplitude oscillatory movement of the meter pointer. If the meter pointer oscillates, rotate A3R5 ccw until oscillation stops.

Figure 3-2. DC Voltage Measurements



(1) Depress the AC power switch (neon-switch combination).

(2) Set FUNCTION SELECTOR to the polarity desired (+DCA or -DCA).

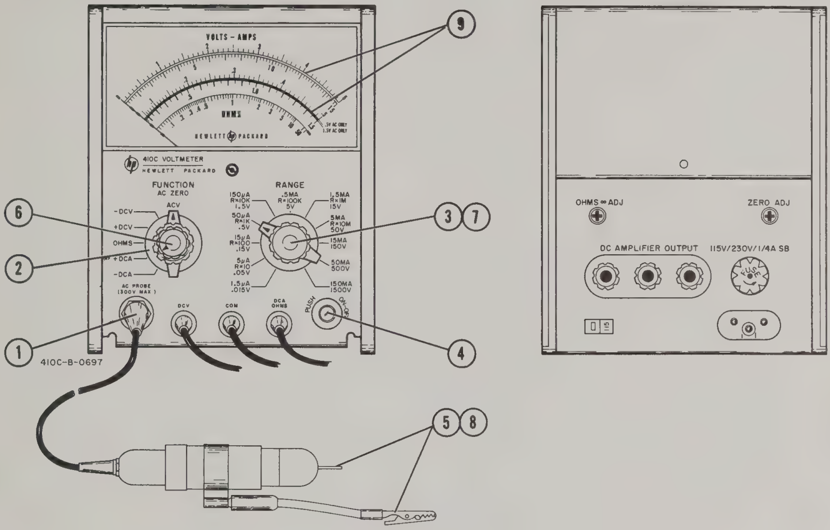
(3) Set range to desired current position.

(4) Connect COM Lead to the ground of circuit under test.

(5) Connect the DCA ohms probe to the circuit to be tested.

(6) Read the current on the VOLTS-AMPS scale.

Figure 3-3. DC Current Measurements



CAUTION

CONNECT AC GROUND CLIP AND COM LEAD TO EARTH GROUND ONLY WHEN IN AC FUNCTION.

1. Connect the hp Model 11036A AC Probe to the Model 410C at the AC PROBE receptacle.

2. Set FUNCTION SELECTOR to ACV. NOTE: COM and chassis are internally connected when the FUNCTION SELECTOR is set to ACV.

3. Set RANGE to 0.5 V.

4. Depress the AC power button (neon-switch combination) and allow 5 minute warmup.

5. Short AC Probe Tip with Ground Clip.

6. Adjust AC ZERO for a zero indication on the meter.

7. Set RANGE to the desired voltage range.

8. Connect AC Probe clip (alligator) to ground of circuit to be tested, and touch probe tip to test point. At lower frequencies COM Lead can be substituted for the AC probe clip.

CAUTION

BEFORE MEASURING VOLTAGES AT FREQUENCIES ABOVE 100 MC, REFER TO FIGURE 3-5 TO DETERMINE THE MAXIMUM AMOUNT OF VOLTAGE THAT CAN BE APPLIED AT THAT FREQUENCY.

9. Read AC voltage on the VOLTS-AMPS scale. NOTE: When RANGE is on the 0.5 V and 1.5 V positions, use red meter scale.

Figure 3-4. AC Voltage Measurements

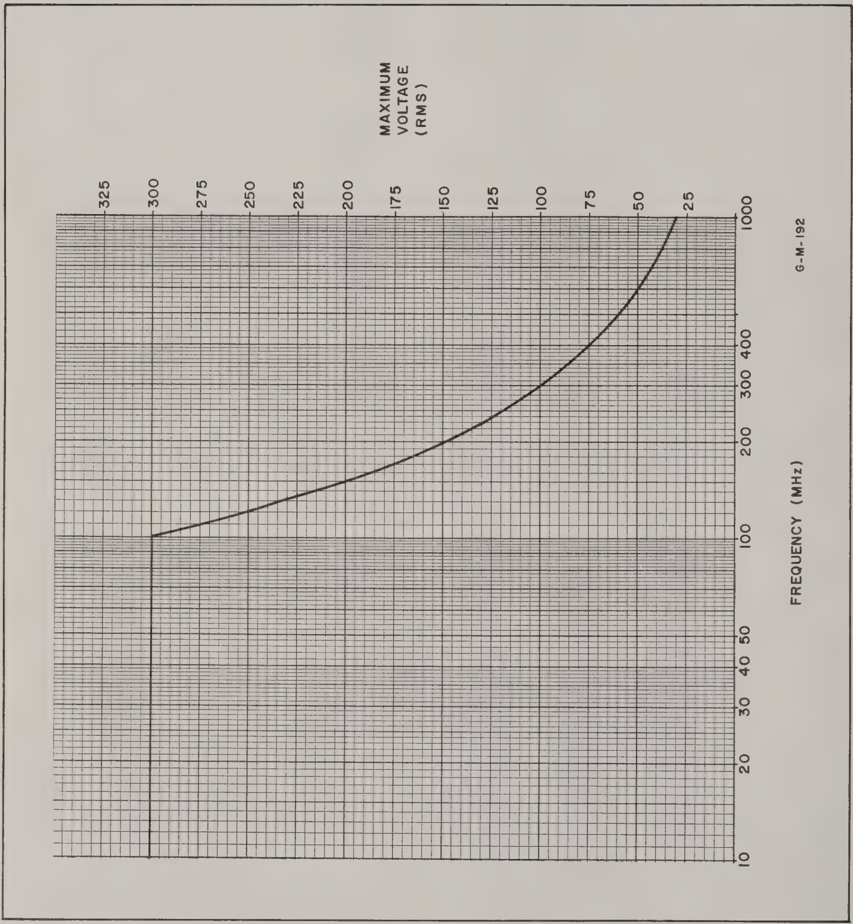


Figure 3-5. Maximum AC Voltage Chart for 11036A AC Probe

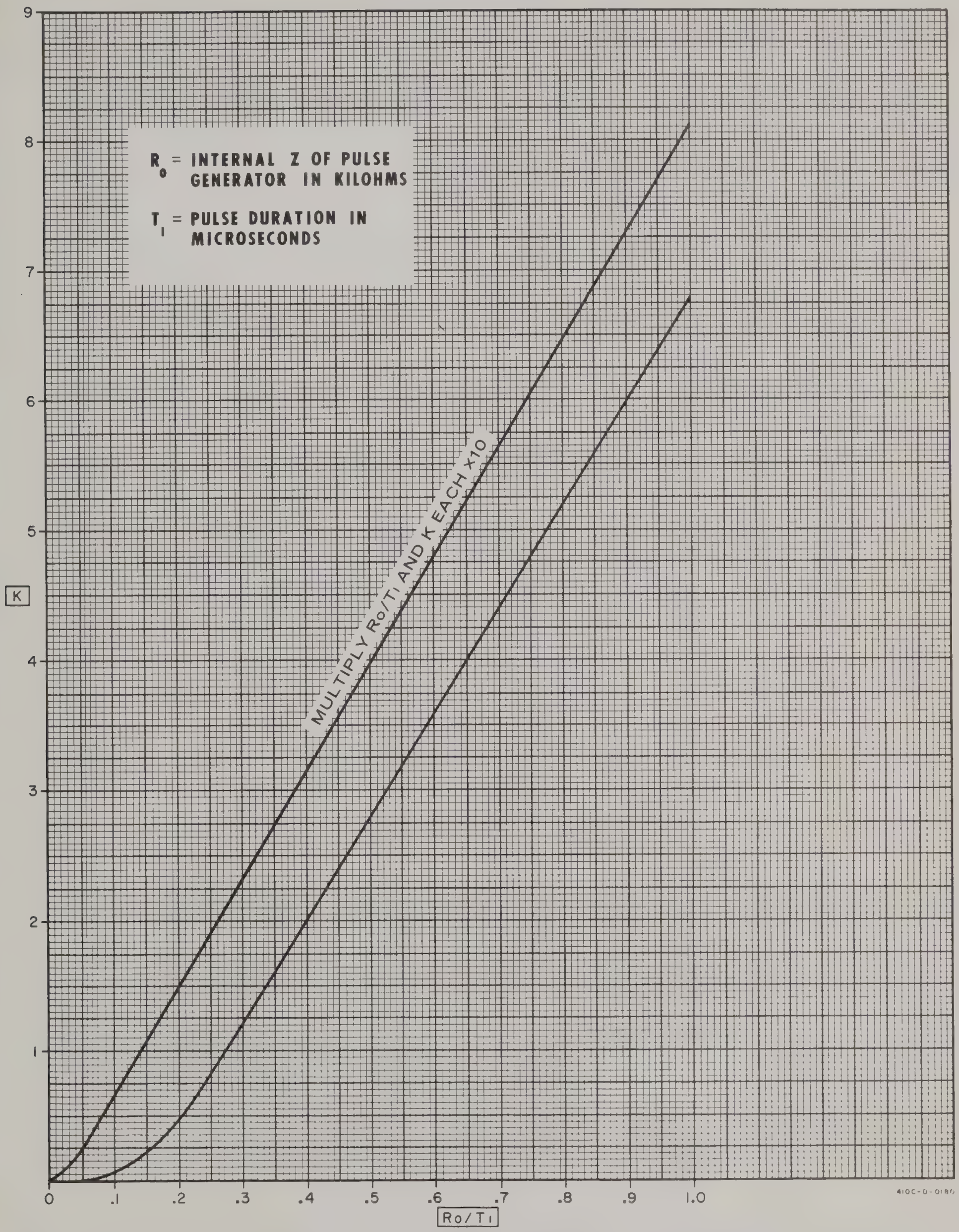
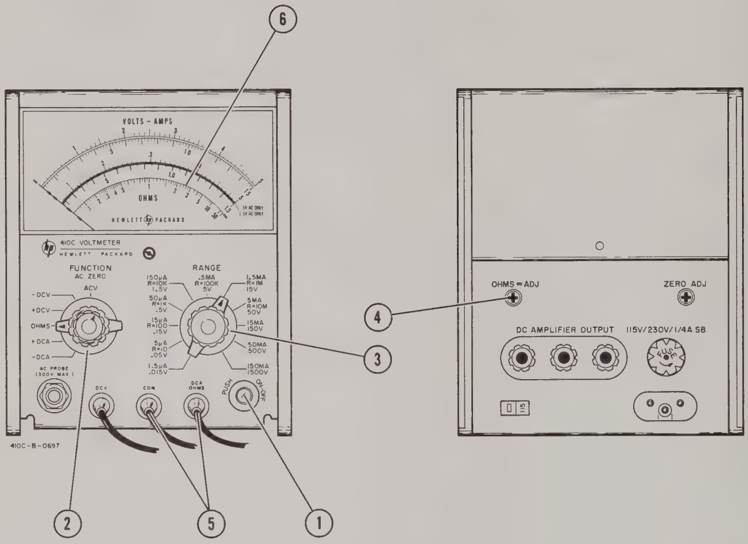


Figure 3-6. Graph Used in Calculation of Pulse Voltage Readings



Before making resistance measurements, remove power from circuit to be tested. Be sure to discharge capacitors to eliminate any residual voltage.

1. Depress AC power switch (neon-switch combination).

2. Set the FUNCTION SELECTOR to OHMS.

3. Set RANGE to desired position.

4. Adjust OHMS ∞ ADJ. control on rear panel to obtain an ∞ reading on the meter if necessary.

5. Connect COM and DCA OHMS leads across circuit to component to be tested.

6. Resistance is determined by multiplying the reading on the OHMS scale by the RANGE factor. EXAMPLE: If reading is 1.5 and factor is 10K, then resistance equals 15K ohms.

Figure 3-7. Resistance Measurements

instructions

FOR THE

HEATHKIT

HEATHKIT MICROPHONE

Model HDP-21A

INTRODUCTION

The HEATHKIT Model HDP-21A Microphone is attractively styled and well constructed.

Its frequency response is especially recommended for voice communications with Heathkit SSB Amateur Radio equipment.

FEATURES

Optimum Frequency Response..... Choice Of Switching Configurations.....Locking Button On Press-To-Talk Lever.....Strong Chrome Plated Die-Cast Zinc.

SPECIFICATIONS

Type.	Dynamic, high impedance.
Frequency Response.	70 Hz to 10 kHz.
Output.	57 db below 1 volt per microbar.
Load Impedance.	100 KΩ, minimum.
Maximum Switch Current.	1 ampere.
Maximum Switch Voltage.	125 volts AC or DC.
Material.	Die-cast zinc and plastic.
Finish.	Satin chrome and gray.
Dimensions.	10" high x 5-1/8" base diameter.
Net Weight.	1-3/4 lbs.

597-358 PRINTED IN U. S. A. 7-25-69

STEP-BY-STEP INSTRUCTIONS

NOTE: The following wiring instructions are for standard VOX and push-to-talk operation, as would be used in all HEATHKIT HW Series Transceivers and SB Series Transceivers and Transmitters. If another type of wiring is required, refer to the Switch Explanation section and Figure 6.

Refer to Figure 1 for the following steps.

( ) Screw the BASE onto the end of the SWITCH RISER opposite the ADJUSTABLE COLLET.

( ) Screw the MICROPHONE onto the top of the SWITCH RISER. Be careful not to strip the threads.

( ) Remove the SWITCH COVER by removing the two Phillips head screws from the back of the SWITCH RISER.

( ) Remove the CABLE CLAMPS from the SWITCH RISER.

( ) Locate the short length of shielded cable. Then prepare both ends and install the microphone connector. Refer to Figure 2.

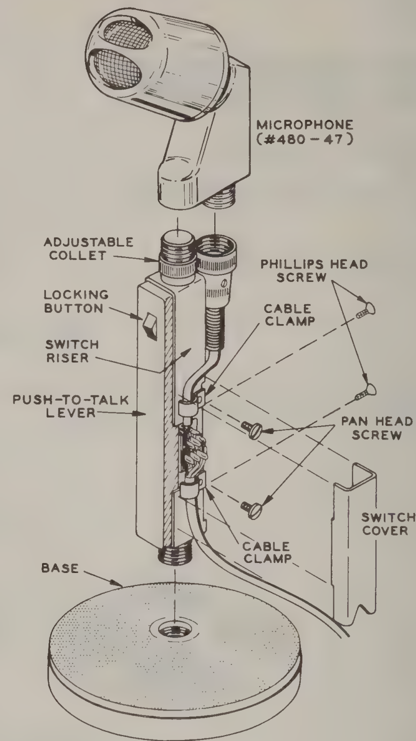


Figure 1

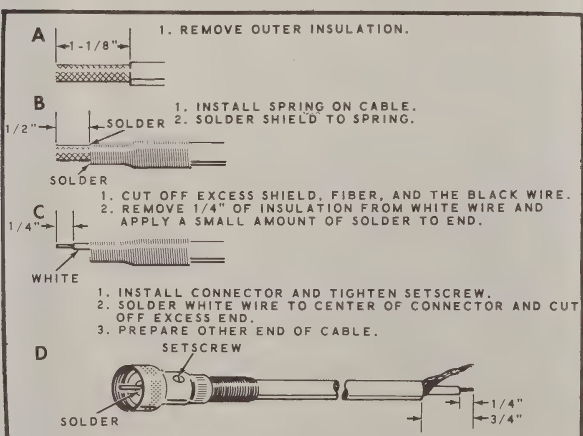


Figure 2

( ) Screw the microphone connector onto the Microphone.

( ) Locate the length of 3-wire cable and prepare one end as shown in Figure 3.

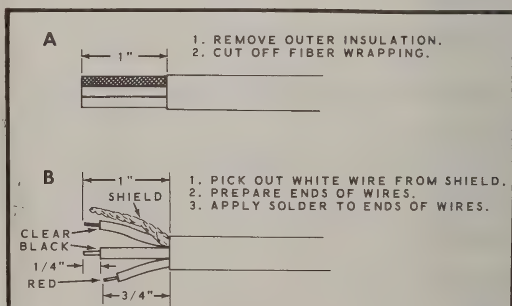


Figure 3

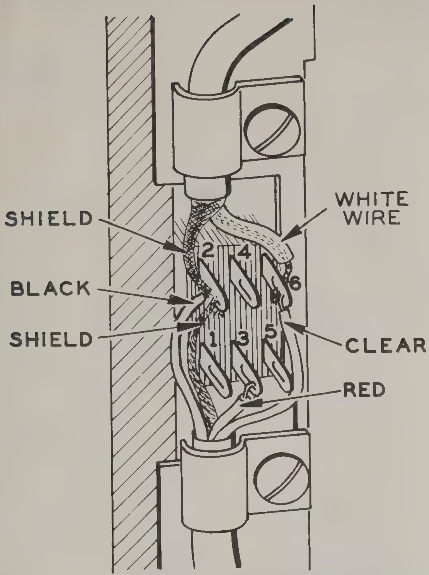


Figure 4

Refer to Figure 4 for the following steps.

Connect the cable coming from the microphone connector to the switch as follows:

( ) Connect the shield to lug 2. Do not solder.

( ) Connect the white wire to lug 6. Do not solder.

Connect the 3-wire cable to the switch as follows:

( ) Connect the shield to lug 2. Do not solder.

( ) Connect the black wire to lug 2. Solder all three connections.

( ) Connect the red wire to lug 3. Solder.

( ) Connect the clear wire to lug 6. Solder both connections.

( ) Position the cables as shown and mount the two CABLE CLAMPS.

( ) Mount the SWITCH COVER with the Phillips head screws.

( ) Cut the 3-wire cable to the correct length for your installation.

( ) Prepare the free end of the 3-wire cable to fit the connector to be used with your equipment. A two or more pin connector is required. Refer to the wiring diagram of your equipment for proper terminations at the connector.

( ) Connect the red wire to the control circuit pin of the cable connector as shown in Figure 5. Solder.

( ) Connect the clear wire to the audio pin of the cable connector as shown in Figure 5. Solder.

( ) Connect the black wire and the shield together, and fold them back along the outside (spring) of the connector.

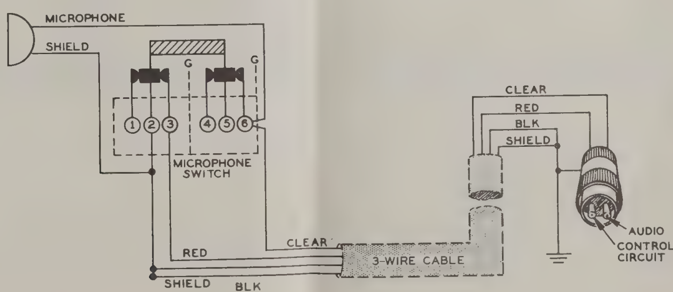


Figure 5

SWITCH EXPLANATION

Figure 6 shows the contact arrangement of the switch used in the Microphone. For switching requirements other than previously given, the following explanation should be helpful.

Contacts 1 and 2 break before 4 and 5 break. Contacts 4 and 5 break before 2 and 3 make. Contacts 2 and 3 make before 5 and 6 make. At G are the contact insulators, and at H is the push-to-talk lever return spring.

If the switch is to be used to operate a relay, be sure to check the Specifications for the maximum current rating of the contacts. It is recommended that wires used to carry high voltage or high current be run separate from the microphone cable.

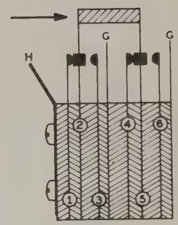


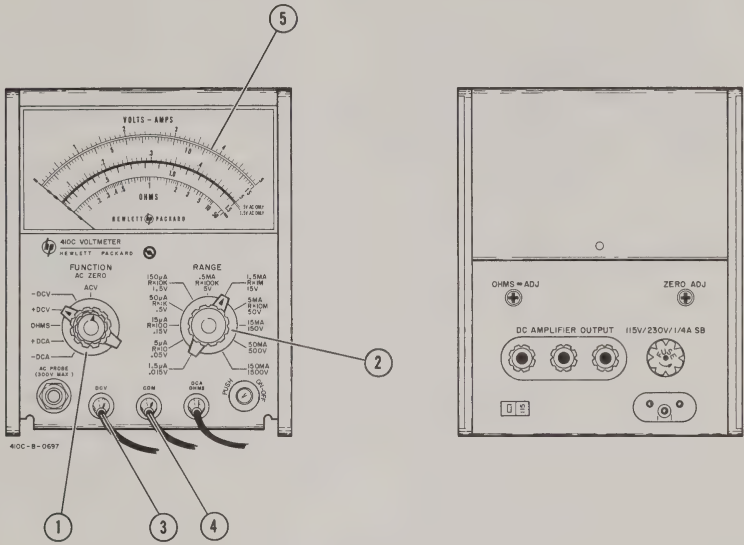
Figure 6

WARRANTY

The Heath Company warrants parts in its kits for 90 days after shipment. Under this warranty, we will exchange any defective part returned prepaid within the 90 days. If a part is defective, its replacement is shipped prepaid by us anywhere in the continental United States or to APO and FPO addresses. Shipments to all other areas are FOB factory. Heath's obligation is limited to such replacement or repair by Heath, and Heath is not responsible under this warranty or otherwise for any consequential damage or other loss in connection with the purchase, assembly, or use of the kit or parts. Use the Parts Order Form in the kit to notify us of the defective part and return instructions will be sent to you, or contact any Heathkit Electronic Center.

Questions relating to repairs or warranty replacement in the continental United States (APO and FPO included) should be addressed to Heath Company, attention: Customer Relations, or the nearest Heathkit Electronic Center. In all other areas please contact the authorized Heathkit representative in your country, or Heath Company, attention: International Division.

HEATH COMPANY
Benton Harbor, Michigan 49022



(1) Set the FUNCTION SELECTOR to +DCV or -DCV (depending on direction of current flow).

(2) Set RANGE to desired range (0.015 V, 0.05 V, or 0.15 V range.

Note

0.015 V range = 1.5 nano-amperes range

0.05 V range = 5.0 nano-amperes range

0.15 V range = 15 nano-amperes range

(3) Connect the DCV lead to the circuit under test.

(4) Connect the COM lead to the circuit under test.

(5) Read nano-amperes from the meter on the VOLTS-AMPS scale (top two on meter) which corresponds to the range selected.

Figure 3-8. DC Nano-Ampere Current Measurements

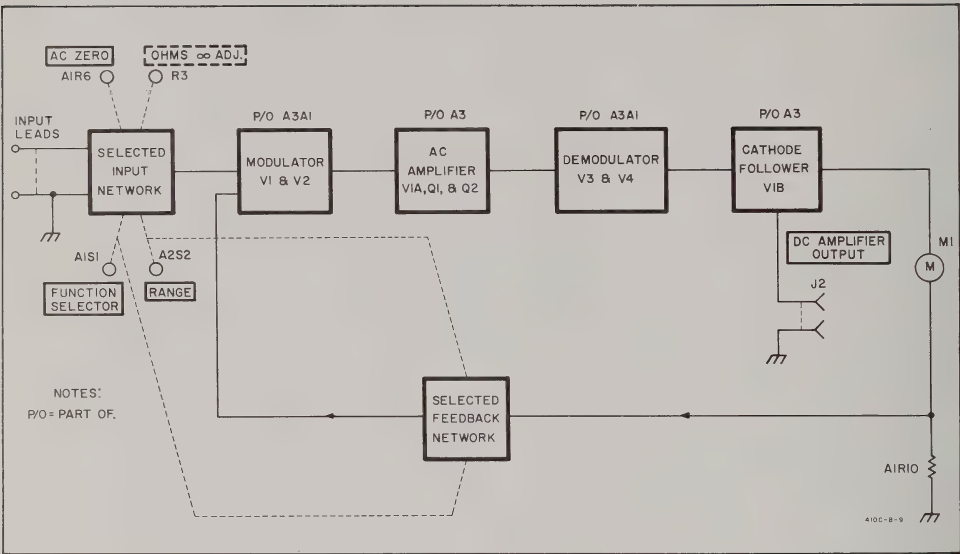


Figure 4-1. Block Diagram, Model 410C

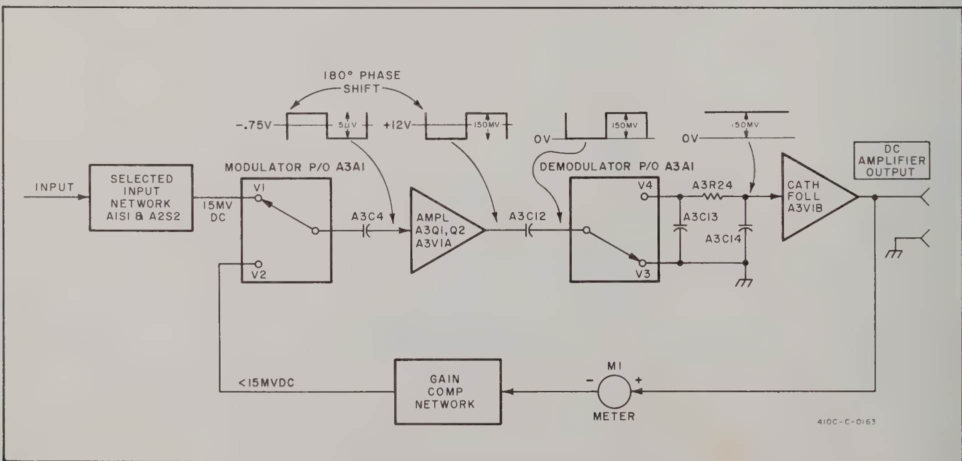


Figure 4-2. Modulator-Demodulator Mechanical Analogy

SECTION IV
THEORY OF OPERATION

4-1. OVERALL DESCRIPTION.

4-2. The Model 410C includes an input network, a modulator - amplifier - demodulator, and a meter circuit. A block diagram of the Model 410C is shown in Figure 4-1.

4-3. Signals to be measured are applied through the appropriate input lead to the input network. AC voltages are detected in the AC probe, and therefore all signals to the input network are DC. The input network attenuates the DC signal to a level determined by RANGE and FUNCTION SELECTOR settings. The attenuated DC voltage is applied to the modulator which converts the DC to AC for amplification. The amplified AC signal is converted back to DC voltage in the demodulator and coupled to cathode follower V1B. The cathode follower output to the DC AMPLIFIER OUTPUT connector and meter circuit is a DC voltage proportional to the amplitude of the signal applied to the input. A portion of the voltage to the meter circuit is returned to the modulator as feedback. When the feedback voltage and attenuated DC voltage are nearly equal, the meter stabilizes.

4-4. CIRCUIT DESCRIPTION.

4-5. INPUT NETWORK.

4-6. The input network includes a precision voltage divider, which by means of the FUNCTION SELECTOR and RANGE switches, provides a maximum of 15 millivolts at the modulator input regardless of the range set and signal applied. The ±DCA, ±DCV, OHMS, and ACV modes of operation are discussed below.

4-7. DC CURRENT MEASUREMENTS: Refer to Figure 4-3, throughout this explanation. The purpose of the input network is to provide proper attenuation of currents applied. Currents from 1.5 μa to 150 ma full scale are applied with input impedance decreasing from 9K ohms on the 1.5 μa range to approximately 0.3 ohms on the 150 ma range.

4-8. The change in input impedance is varied by using DC current shunts in conjunction with RANGE switch A2S1. The DC voltage developed across these shunt resistors, when applied through the modulator-amplifier-demodulator network to the meter, provide a deflection on the meter proportional to the DC current being measured.

4-9. DC VOLTAGE MEASUREMENTS. Refer to Figure 4-4 throughout this explanation. The purpose of the input network is to accurately attenuate the input signal to a maximum of 15 millivolts at the modulator input. The network presents an input impedance of 10 megohms on the three most sensitive ranges and 100 megohms on all other ranges.

4-10. The resistor R1 (located in the DCV probe) in conjunction with resistors A2R10 through A2R26, provides the 10 megohm input impedance required for the three most sensitive DCV ranges. Resistors A2R4 and A3R30 are shunted out of the circuit by the RANGE switch on the three most sensitive DCV ranges.

4-11. When using the eight less sensitive ranges, A2R4 and A3R30 are placed in series with R1 and A2R10 through A2R26 to present more than 100 megohm impedance to the input.

4-12. A3R30 is used to calibrate full scale on the 1500 volt range. (See Paragraph 5-35.)

4-13. RESISTANCE MEASUREMENTS. The purpose of the input network shown in Figure 4-5 is to place approximately 0.6 volt DC source in series with a known (reference) resistance. The resistance to be measured is placed in parallel with the known resistance, which changes the voltage proportionally. The maximum changes in voltage applied to the modulator is 15 mv because of attenuation provided by A2R4, A3R30, and A1R2.

4-14. A DC current of approximately 60 ma is supplied at the junction of A2R22 and A2R23 through A7R10, R3, A2R2 and A2R1 to the input network. The OHMS ∞ ADJ., R3, sets the meter for full scale (∞). Resistor A2R1 is shorted out in the X1M position of the RANGE switch; resistors A2R1 and A2R2 are shorted out in the X10M range. The resistors A2R2 and/or A2R1 are electrically removed from the circuit to increase the voltage at the junction of A2R22 and A2R23. This is done to compensate for the loading of the attenuator (A2R4, A3R30, and A1R2) on these ranges.

4-15. AC VOLTAGE MEASUREMENTS. Refer to Figure 4-6 throughout this explanation. Voltage at the AC probe is converted to DC and applied to the input network. The input signal is attenuated to produce a maximum of about 15 millivolts at the modulator input. AC zero adjustment of meter pointer is made with the AC ZERO control.

4-16. MODULATOR-DEMODULATOR.

4-17. Refer to the Amplifier Schematic, Figure 5-11, and to the Mechanical Analogy Schematic, Figure 4-2 throughout this explanation.

4-18. The input network applies approximately 15 millivolts DC, for full scale meter deflection (positive or negative, depending on the polarity of the

voltage or current being measured) to the neon-photoconductor chopper. Also applied to the opposite side of the chopper is the amplifier feedback voltage, which is of the same polarity and approximately 5 microvolts lower in amplitude than the input voltage. The modulator-chopper consists of two photoconductors, A3A1V1 and A3A1V2, which are alternately illuminated by two neon lamps, A3A1DS1 and A3A1DS2, respectively. The neon lamps are part of a relaxation oscillator whose frequency is controlled by A3R5. The oscillator frequency is nominally set to 100 Hz for operation from 60 Hz power line, or to 85 Hz for 50 Hz line. This frequency is selected so that it is not harmonically related to the power line frequency, precluding possible beat indications on the meter.

4-19. As the photoconductors are alternately illuminated by the neons, their respective resistances are low (conductive) when illuminated and high (non-conductive) when darkened. Therefore, the input voltage and feedback voltage are alternately applied to the input amplifier. The amplitude of the resultant signal to the amplifier is the voltage difference between the input and feedback voltages.

4-20. The chopped DC signal is amplified by a three stage RC amplifier, consisting of A3V1A, A3Q1 and A3Q2. The amplified signal to the input of the demodulator-chopper is 180° out of phase with the output of the modulator-chopper.

4-21. The demodulator-chopper consists of two photoconductors, A3A1V3 and A3A1V4, which are alternately illuminated by neon lamps A3A1DS1 and A3A1DS2, respectively. Approximately 150 millivolts square-wave is applied to the demodulator from the amplifier. Since the same neon lamps illuminate both the modulator and demodulator photoconductors, operation of the two choppers is synchronous. Therefore, when A3A1V1 is sampling the input voltage, A3A1V3 is clamping the amplified and inverted difference voltage to ground. Alternately, when A3A1V2 is sampling the feedback voltage, A3A1V4 is charging capacitors A3C13 and C3C14 to the peak value of the square-wave. These capacitors maintain this charge so long as the input voltage remains constant by virtue of having no discharge path and because they are being repetitively recharged by the demodulator.

4-22. Therefore, a DC potential, proportional to the difference between the input and feedback voltages, is applied to the grid of the cathode follower and subsequently to meter circuit and DC AMPLIFIER OUTPUT connector. A portion of the meter circuit voltage is fed back to the modulator. The meter stabilizes when the feedback voltage and input voltages are nearly equal.

4-23. THE FEEDBACK NETWORK.

4-24. The feedback network drives the meter and determines the DC gain of the amplifier. The feedback is varied depending on the position of the FUNCTION and RANGE selectors. The different feedback configurations are discussed below.

4-25. FEEDBACK NETWORK FOR ±DCA, OHMS, AND ±DCV. Figures 4-3, 4-4 and 4-5 show the feedback configuration for all positions of the FUNCTION SELECTOR except ACV. The meter is electrically inverted for ±DCV and ±DCA modes of operation. The DC OUTPUT ADJ., A6R20 sets the output voltage. The DC pot, A6R18 determines the amount of feedback to the modulator. The resistor A2R30 is in the circuit in the ±.015 DCV and ±1.5 μa modes of operation, to decrease feedback and thus increase amplifier gain to compensate for the decrease in input signal to the modulator on these ranges.

4-26. FEEDBACK CIRCUIT FOR AC VOLTAGE MEASUREMENTS. Figure 4-6 shows the feedback configuration for the ACV position of the FUNCTION SELECTOR switch, A1S1. The resistors that are placed in the circuit by the RANGE switch program the amplifier gain to compensate for the non-linear response of the AC probe. A6R16 and A6CR1 compensate the non-linear response of the AC probe to the linear calibration of the upper meter scale on the 5 volt range.

4-27. POWER SUPPLY.

4-28. PRIMARY POWER. Refer to Figure 5-9 through-out this explanation. Either 115 or 230 volt ac power is connected through fuse F1 (0.25 amp slow-blow) and switch S1 to the primary of power transformer T1. Switch S2 connects T1 primaries in parallel for 115 volt operation of in series for 230 volt operation.

4-29. UNREGULATED AND ZENER REGULATED POWER SUPPLY. Full wave rectifier CR1 and CR2 produces unregulated +270 volts, which is used to drive the photochopper neons. Unregulated +175 volts and +140 volts are tapped off and are used to provide B+ to the plates of A3V1B and A3V1A, respectively. Zener regulators A7CR6 and CR7 provide regulated +38 volts and -9 volts to bias A3Q1 and A3Q2. Filtering of the outputs is provided by the RC network consisting of A7R1 through A7R3 and C5A through C5D.

4-30. SERIES REGULATED POWER SUPPLY. The output of the full wave rectifier CR3 and CR4 is regulated by transistor Q1, which is connected in series with the output. Zener diode A7CR8 provides reference voltage to the base of Q1. Regulated +6 volts is supplied to the filaments of A3V1A/B and the AC Probe diode A8V1. +0.6 volts is provided through A7R10 to R3, the OHMS ∞ ADJ. control. Filtering of the outputs is provided by C6A and C6B.

4-31. STANDBY FILAMENT SUPPLY. The filament tap (T1, Pins 1 and 2) provides 6.0 volts ac to the filament of the AC probe diode, A8V1, so that the filament remains warm when the Model 410C is being used in modes of operation other than ACV. When FUNCTION selector A1S1 is switched to ACV, 6.0 volts AC is removed from the filament and 6 volts DC is applied. Therefore, the ACV mode is ready for immediate use, without waiting for the filament to warm up.

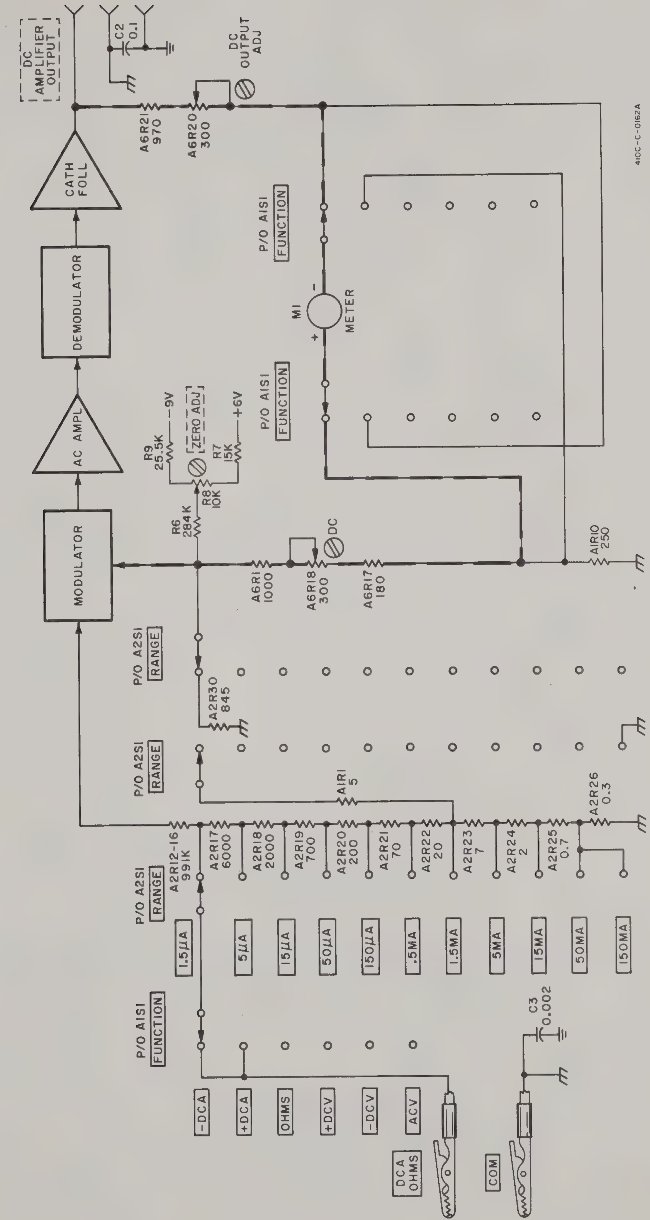


Figure 4-3. Simplified Schematic, DC Current Measurement

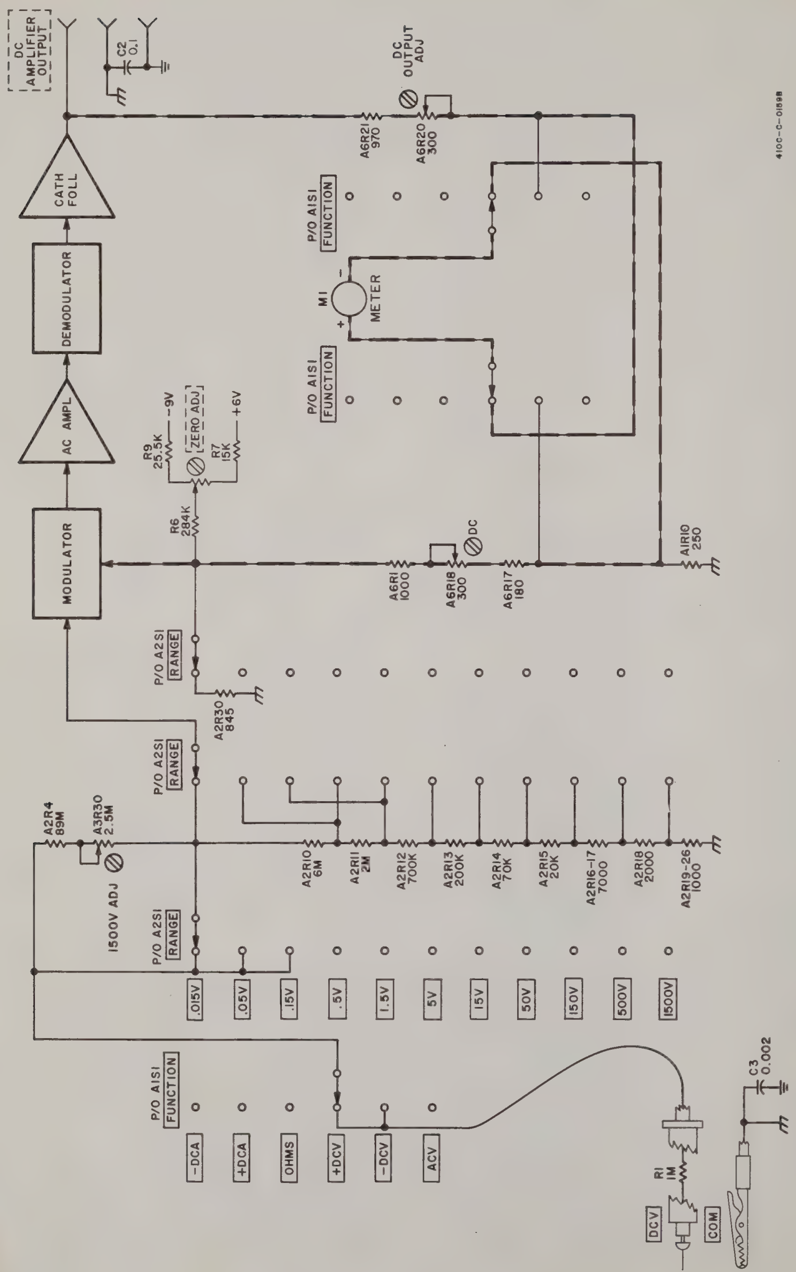


Figure 4-4. Simplified Schematic, DC Voltage Measurements

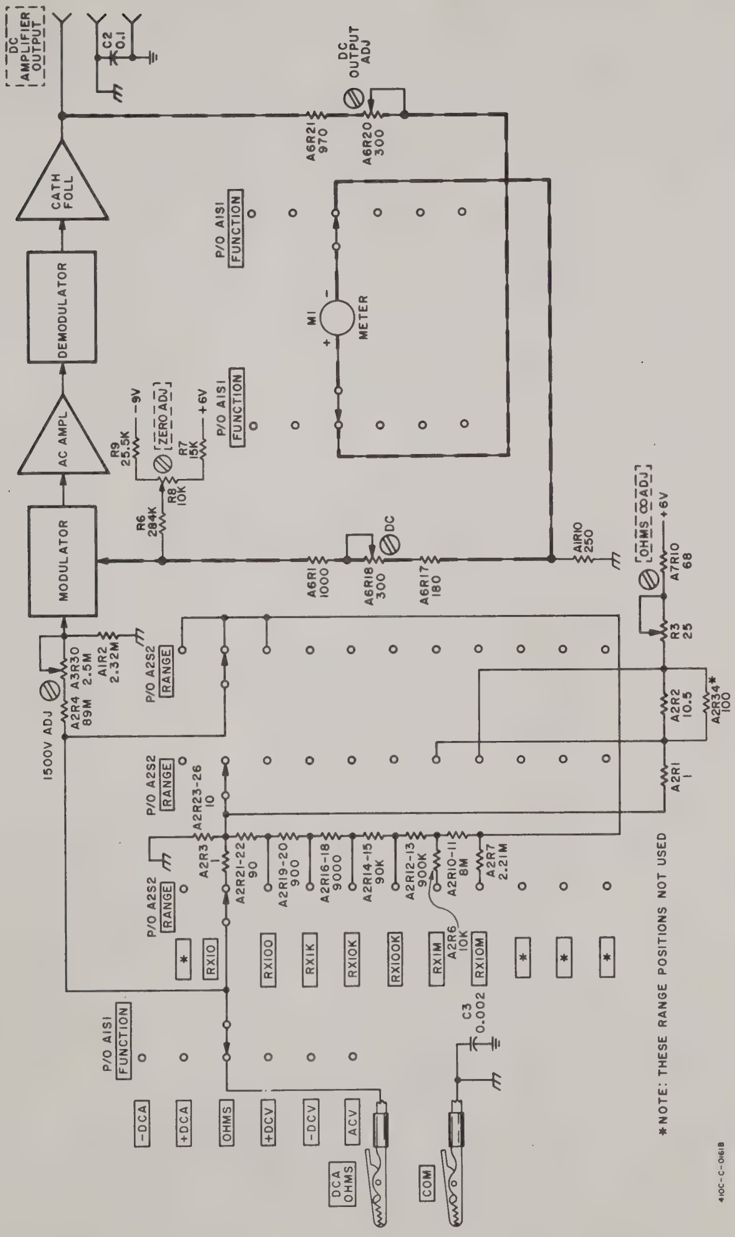


Figure 4-5. Simplified Schematic, Resistance Measurement

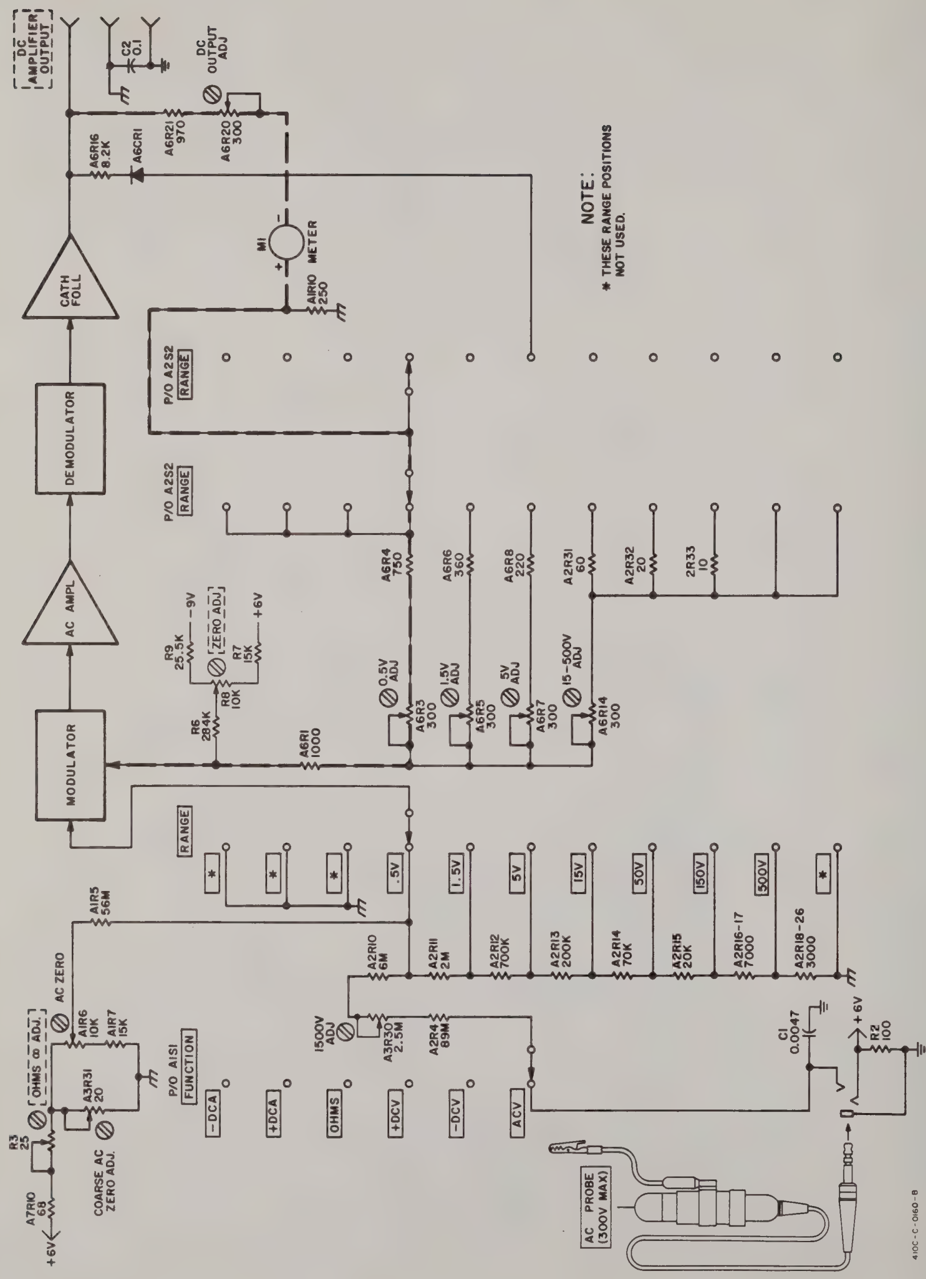


Figure 4-6. Simplified Schematic, AC Voltage Measurement

Table 5-1. Recommended Test Equipment

Instrument Type	Required Characteristics	Use	Recommended Model
Voltmeter Calibrator	Range: 0.015 to 300 v Frequency: Dc and 400 Hz Accuracy: ±0.3% ac ±0.2% dc	AC and DC Accuracy Checks and Calibration Adjustments	hp Model 738BR Voltmeter Calibrator
Oscillator	Frequency: 20 Hz to 10 MHz Output: 2.0 v	Frequency Response Test	hp Model 652A Test Oscillator
DC Power Supply	Range: 0 to 10 v continuous	DC Ammeter Accuracy Checks	hp Model 723A DC Power Supply
DC Voltmeter	Range: 10 v Accuracy: ±0.2%	Accuracy Checks; Power Supply Measurements; Troubleshooting	hp Model 3440A/3441A/3443A Digital Voltmeter
VHF Signal Generator	Frequency: 10 MHz to 400 MHz Output: 1.0 v	Frequency Response Test	hp Model 608 VHF Signal Generator
UHF Signal Generator	Frequency: 480 MHz to 700 MHz	Frequency Response Test	hp Model 612A UHF Signal Generator
AC Voltmeter	Range: 120 v	Power Supply Measurements (ripple)	hp Model 3400A RMS Voltmeter
Electronic Counter	Frequency Range: to at least 102 Hz	Chopper Frequency Adjust	hp Model 5211A Electronic Counter
Ohmmeter	Range: 100 M Ω Accuracy: ±5%	Troubleshooting	hp Model 412A DC VTVM
Micro-Potentiometer	Frequency Range: 10 MHz to 700 MHz Output Voltage: 0.44 v rms Accuracy: NBS calibrated	Frequency Response Test	Ballantine Model 440 Micro-Potentiometer
Probe-T-Connector	For use with 50 ohm transmission line	Frequency Response Test	hp Model 11042A Probe-T-Connector
Connector Adapter	Type N male to BNC female	Frequency Response Test	hp Part No. 1250-0067
Connector Adapter	BNC to binding post	Frequency Response Test	hp Part No. 10110A
Connector Adapter	Type "N" male to Type "N" female	Frequency Response Test	hp Part No. 11501A
50 Ω termination	Frequency Range: 10 MHz to 700 MHz Low reflection	Frequency Response Test	hp Part No. 908A
50 ohm feed-thru	Male BNC to female BNC	Performance Checks	hp Model 11048B
Resistors:			
10 M Ω	Accuracy: ±1%	Performance Checks	hp Part No. 0730-0168
56 K	Accuracy: ±1%	Performance Checks	hp Part No. 0730-0053
10 K	Accuracy: ±1%	Performance Checks	hp Part No. 0727-0157
1 K	Accuracy: ±1%	Chopper Frequency Adjust	hp Part No. 0727-0751
1.5 K	Accuracy: ±1%	Performance Checks	hp Part No. 0730-0017
56 ohms	Accuracy: ±1%	Performance Checks	hp Part No. 0811-0341
10 ohms	Accuracy: ±1%	Performance Checks	hp Part No. 0727-0335

SECTION V
MAINTENANCE

5-1. INTRODUCTION.

5-2. This section contains maintenance procedures for the Model 410C Electronic Voltmeter.

5-3. TEST EQUIPMENT REQUIRED.

5-4. The test equipment required to maintain and adjust the Model 410C is listed in Table 5-1. Equipment having similar characteristics may be substituted for items listed.

5-5. PERFORMANCE CHECKS.

5-6. The performance checks presented in this section are front panel operations designed to compare the Model 410C with its published specifications. These operations may be incorporated in periodic maintenance, post repair and incoming quality control checks. These operations should be conducted before any attempt is made at instrument calibration or adjustment. During performance checks, periodically vary the line voltage to the Model 410C, ±10% on either 115 v or 230 v operation. A 1/2 hour warm-up period should be allowed before these tests are conducted.

5-7. ALTERNATE CALIBRATION VOLTAGE SOURCE.

5-8. Should it be necessary to use the ⓗⓟ Model 738AR Voltmeter Calibrator to conduct these Performance Checks, the arrangement described in Figure 5-1 will provide the necessary voltage values required. However, the ⓗⓟ Model 738BR Voltmeter Calibrator is the preferred instrument for these operations.

5-9. MECHANICAL METER ZERO.

a. Turn instrument on. Allow at least a 20 minute warm-up period.

b. Turn voltmeter off, and allow 30 seconds for all capacitors to discharge.

c. Rotate mechanical zero-adjustment screw on front panel clockwise until pointer reaches zero, moving up scale.

d. If for some reason the pointer should overshoot zero, repeat step c until desired results are obtained.

e. When pointer has been positioned at zero, rotate zero-adjust screw slightly counterclockwise to free it. If meter pointer moves to the left during this action, repeat steps c and e.

5-10. DC VOLTMETER OPERATION.

5-11. ACCURACY CHECK (DCV).

a. Short Model 410C DCV probe to COM lead; set pointer to zero using rear panel adjustment (ZERO ADJ).

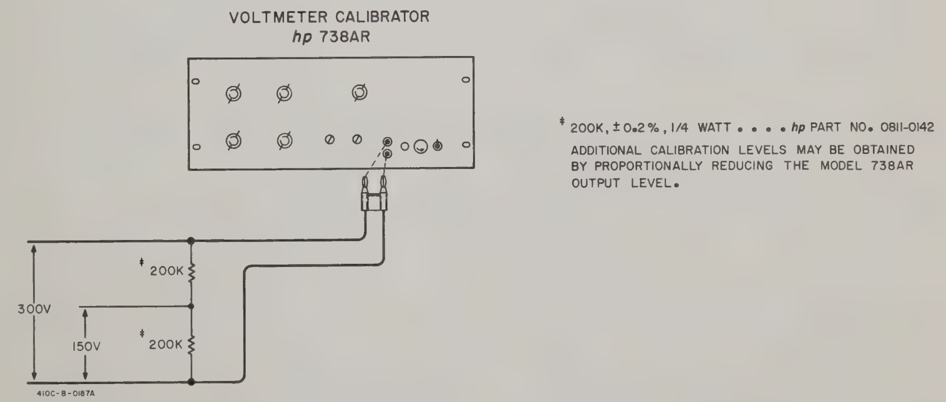


Figure 5-1. Alternate Calibration Voltage Source

b. Set the Model 410C FUNCTION SELECTOR to the +DCV position; RANGE switch to .015 V. Connect Model 410C DCV and COM cables to the Voltmeter Calibrator (hp Model 738BR) output terminals.

c. Adjust voltmeter calibrator and Model 410C to settings listed in Table 5-2.

d. Model 410C should indicate readings within limits specified. If not, refer to Paragraph 5-33 for adjustment procedure.

Table 5-2. DCV Accuracy Test

Model 410C Range Settings	Voltmeter Calibrator Settings Voltage	Model 410C Meter Readings
.015 V	±.015	.0147 to .0153 V
.05 V	±.05	.049 to .051 V
.15 V	±.15	.147 to .153 V
.5 V	±.5	.49 to .51 V
1.5 V	±1.5	1.47 to 1.53 V
5 V	±5	4.9 to 5.1 V
15 V	±15	14.7 to 15.3 V
50 V	±50	49 to 51 V
150 V	±150	147 to 153 V
500 V	±300	290 to 310 V
1500 V	±300	270 to 330 V

5-12. INPUT RESISTANCE CHECK (DCV).

a. Connect a digital voltmeter (-hp- 3440A/3441A) to the DC Amplifier Output. Set digital voltmeter range to 10 V.

b. Set 410C RANGE to .015, FUNCTION to +DC VOLTS.

c. Connect voltmeter calibrator to the 410C DC VOLTS probe and set calibrator output to +.015 V.

d. Adjust A6R20 for digital voltmeter reading of 1.500 V.

e. Connect a 10 megohm ±1% resistor (-hp- Part No. 0730-0168) in series between the voltmeter calibrator and the 410C probe.

f. Adjust calibrator and 410C to settings listed in Table 5-3. Digital voltmeter readings should be within the limits shown for each case.

g. Set 410C RANGE to 500 V. Connect short across 10 megohm resistor in series with input. Set calibrator output to +300 V.

h. Adjust A6R20 for digital voltmeter reading of 0.900 V.

i. Disconnect short across 10 megohm resistor. Digital voltmeter reading should be between 0.815 and 0.821 V, verifying an input resistance of 100 megohms ±1%.

j. Set 410C RANGE to 1500 V. Connect short across 10 megohm resistor and adjust A6R20 for digital voltmeter reading of 0.300 V.

k. Disconnect short across 10 megohm resistor. Digital voltmeter should read between 0.265 and 0.280 V, verifying an input resistance of 100 megohms ±1%.

5-13. DC AMMETER OPERATION.

5-14. ACCURACY CHECK (DCA).

a. Figure 5-2 describes the test arrangement required for this operation.

b. Connect the Model 410C as shown in Figure 5-2; FUNCTION SELECTOR to +DCA; RANGE to 150 MA.

c. Use 56 ohm resistor for R1 and 10 ohm resistor for R2.

d. Adjust dc power supply to obtain reading on dc voltmeter specified in Table 5-4; change R_1 and R_2 according to Table 5-4.

e. Model 410C should read within limits specified in Table 5-4. If not, refer to Paragraph 5-33 for adjustment procedure.

5-15. OHMMETER OPERATION.

5-16. OHMMETER ACCURACY CHECK.

a. A 10 ohm ±1% resistor (hp Part No. 0727-0335) and a 10 M ±1% resistor (hp Part No. 0730-0168) will be required for this test.

Table 5-3. DCV Input Resistance Check

Model 410C Range Settings	Voltmeter Calibrator Settings Voltage	Model 3440/41A Voltage Readings	Model 410C R_{in}
.015 V	.015	0.743 to 0.757	10 MΩ ±1%
.05 V	.05	0.743 to 0.757	10 MΩ ±1%
.15 V	.15	0.743 to 0.757	10 MΩ ±1%
.50 V	.50	1.359 to 1.369	100 MΩ ±1%
1.5 V	1.5	1.359 to 1.369	100 MΩ ±1%
5 V	5	1.359 to 1.369	100 MΩ ±1%
15 V	15	1.359 to 1.369	100 MΩ ±1%
50 V	50	1.359 to 1.369	100 MΩ ±1%
150 V	150	1.359 to 1.369	100 MΩ ±1%

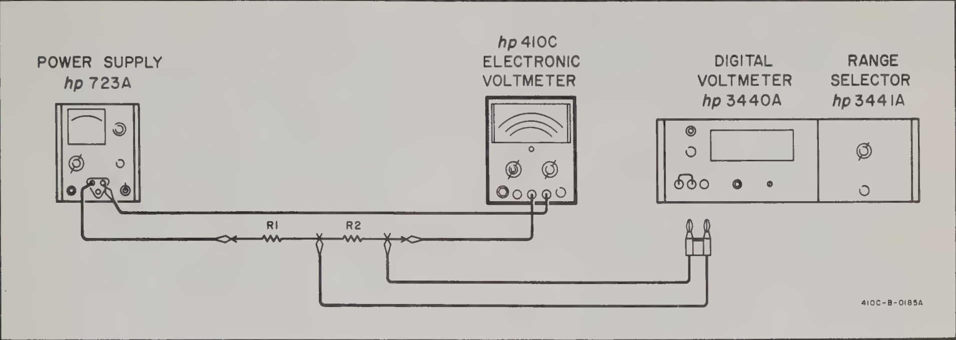


Figure 5-2. DC Ammeter Operation

Table 5-4. DCA Accuracy Test

Model 410C Range Settings	DC Voltmeter Readings	Model 410C Meter Readings	R_1 Ω	R_2 Ω
150 MA	1.4 V	135.5 to 144.5 MA	56	10
50 MA	.4 V	38.5 to 41.5 MA	56	10
15 MA	.14 V	13.55 to 14.55 MA	56	10
5 MA	.04 V	3.85 to 4.15 MA	56	10
1.5 MA	.014 V	1.35 to 1.45 MA	56	10
.5 MA	.004 V	0.385 to 0.415 MA	56	10
150 μa	1.38 V	133.5 to 142.5 μa	56 K	10 K
50 μa	0.46 V	44.5 to 47.5 μa	56 K	10 K
15 μa	0.138 V	13.35 to 14.25 μa	56 K	10 K
5 μa	0.046 V	4.45 to 4.75 μa	56 K	10 K
1.5 μa	0.014 V	1.36 to 1.45 μa	56 K	10 K

b. Set Model 410C FUNCTION SELECTOR to OHMS; RANGE to RX10.

c. Set pointer to ∞ using rear panel adjustment (OHMS ADJ) if required.

d. Connect COM and DCA OHMS cables across 10 ohm resistor.

e. Meter should read 10 ohms (±5%).

f. Set Model 410C RANGE to RX10M. Replace 10 ohm resistor with 10 M ohm resistor.

g. Meter should read 10 M ohms (±5%).

h. If both of these ranges function properly, it can be assumed that the remainder will also. If meter does not function properly, refer to Paragraph 5-36 for adjustment procedure.

5-17. AMPLIFIER OPERATION.

5-18. AMPLIFIER GAIN CHECK.

a. Connect Voltmeter Calibrator (hp Model 738BR) output to Model 410C DCV and COM cables.

b. Connect DC Voltmeter (hp Model 3440A/3441A) to DC AMPLIFIER OUTPUT on rear panel of Model 410C. Set DC Voltmeter RANGE to 10 V.

c. Set Model 410C FUNCTION SELECTOR to +DCV; RANGE to .015 V.

d. Adjust voltmeter calibrator for +.015 VDC output.

e. The dc voltmeter should read +1.5 v. This will verify a gain of 100, where the gain equals $E_{DC\ out} / E_{DC\ in}$.

f. If dc voltmeter does not read at least 1.5 v, refer to Paragraph 5-37 for proper adjustment procedure.

5-19. AC REJECTION CHECK.

a. An Oscillator (hp Model 200SR) and an RMS Voltmeter (hp Model 3400A) are required for this check.

b. Set 410C FUNCTION SELECTOR to -DCV; RANGE to .015 V.

c. Connect Oscillator output to Model 410C DCV and COM cables and input of rms voltmeter. Set rms voltmeter to read 10 v.

d. Adjust test oscillator to provide 3.18 v (4.5 v peak) reading on rms voltmeter at 50 cps.

e. Model 410C should not read more than 2.25 mv verifying 66 db ac rejection at 50 cps.

f. Increase frequency to check ac rejection above 50 cps.

g. Switch Model 410C FUNCTION SWITCH to +DCV and repeat steps e and f.

5-20. OUTPUT LEVEL CHECK.

a. A Voltmeter Calibrator (hp Model 738BR) and a DC Voltmeter (hp Model 3440A/3441A) will be required for this check.

b. Connect dc voltmeter to dc amplifier OUTPUT on Model 410C rear panel. Place ground lead between Model 410C circuit ground and earth ground terminals. Set dc voltmeter RANGE to 10 V.

c. Set Model 410C FUNCTION SELECTOR to +DCV; RANGE to 1.5 V.

d. Adjust Voltmeter Calibrator to provide +1.5 v.

e. Model 410C and dc voltmeter should read 1.5 v.

f. If dc voltmeter does not read at least 1.5 v, refer to Paragraph 5-37 for proper adjustment procedure.

5-21. AMPLIFIER OUTPUT IMPEDANCE CHECK.

a. Connect an external DC Voltmeter (hp Model 3440A/3441A) to Model 410C DC AMPLIFIER OUTPUT terminals on rear panel.

b. Set Model 410C FUNCTION SELECTOR to OHMS position; RANGE to RX10K.

c. Record voltage indicated on external dc voltmeter for use as a reference.

d. Connect a 1.5 K ohm ±1% resistor (hp Part No. 0730-0017) across Model 410C DC AMPLIFIER OUTPUT terminals. Dc voltage recorded in step c above should not change more than 3 mv, indicating that dc amplifier output impedance is within the 3 ohm specification at dc.

5-22. AMPLIFIER NOISE CHECK.

a. Connect external DC Voltmeter (hp Model 3440A/3441A) to the DC AMPLIFIER OUTPUT of Model 410C.

b. Set the Model 410C FUNCTION SELECTOR to +DCV; RANGE to 1500 V.

c. Short the Model 410C DCV and COM cables. External dc voltmeter reading should be less than 7.5 mv.

d. Reset Model 410C RANGE to 1.5 V. DC Voltmeter should read less than 7.5 mv.

NOTE

If Model 410C DC OUTPUT is used for recording, the chopper frequency can be adjusted to minimize output noise. Refer to Paragraph 5-31.

5-23. OVERLOAD RECOVERY CHECK.

a. Connect Voltmeter Calibrator (hp Model 738BR) output to Model 410C DCV and COM cables.

b. Set Model 410C FUNCTION SELECTOR to +DCV; RANGE to .15 V.

c. Adjust voltmeter calibrator for +0.15 vdc; note reading on Model 410C.

d. Readjust voltmeter calibrator for +15 VDC output; wait 5 seconds for complete saturation; then switch voltmeter calibrator back to +.15 VDC output. Note time required for meter to return to original position.

e. Recovery time should be less than 3 sec.

5-24. AC VOLTMETER OPERATION.

CAUTION

WHEN MEASURING AC VOLTAGES, DO NOT PERMIT AC GROUND JUMPER OF MODEL 410C AC PROBE TO CONTACT UNGROUNDED SIDE OF AC SOURCE OR SERIOUS DAMAGE TO 410C WILL RESULT.

5-25. AC VOLTMETER ACCURACY CHECK.

a. Set Model 410C RANGE to 0.5 V. Short the input of the AC Probe. Adjust ZERO vernier for zero pointer deflection.

b. Connect ACV probe to the Voltmeter Calibrator (hp Model 738BR).

c. Adjust voltmeter calibrator for 400 cps-rms output.

d. Set Model 410C FUNCTION SELECTOR to ACV; RANGE to 500 V.

e. Adjust the voltmeter calibrator to settings listed in Table 5-5. Model 410C should indicate readings within limits specified. If not, refer to Paragraph 5-38 for corrective action. Record Model 410C reading with 0.3 v input.

NOTE

The frequency response tests are performed using reference voltage obtained with 0.3 v input.

Table 5-5. AC Accuracy Test

410C Range	Voltmeter Calibrator 400 Hz Voltage Selection	Model 410C Readings
500 V	300	285 to 315 V
150 V	150	145.5 to 154.5 V
50 V	50	48.5 to 51.5 V
15 V	15	14.55 to 15.45 V
5 V	5	4.85 to 5.15 V
1.5 V	1.5	1.455 to 1.545 V
.5 V	0.5	0.485 to .515 V
.5 V	0.3	0.285 to .315 V

5-26. AC VOLTMETER LOW FREQUENCY RESPONSE CHECK.

a. A Test Oscillator (-hp-Model 652A), a BNC-to-Binding Post Adaptor (-hp- Part No. 10110A) and a 50 ohm Feed-thru Termination (-hp-Part No. 11048B) are required for this check.

b. Connect Model 410C as shown in Figure 5-3.

c. Set Model 410C FUNCTION SELECTOR to ACV; RANGE to 0.5 V.

d. Set Test Oscillator frequency to 400 Hz, and adjust amplitude to give same 410C reading as recorded in Paragraph 5-25, step e, with 0.3 V input.

e. Set Test Oscillator REF SET to convenient level.

f. Adjust frequency of Test Oscillator to various cardinal points between 20 Hz and 10 MHz, resetting amplitude to reference level set in step c for each frequency. Model 410C readings should be the same as the reading set at 400 Hz in step d ±10% from 20 Hz to 100 Hz and ±2% from 100 Hz to 10 MHz.

5-27. AC VOLTMETER HIGH FREQUENCY RESPONSE CHECK.

a. A VHF Signal Generator (-hp- Model 608C), a UHF Signal Generator (-hp- Model 612A), a Probe-T-Connector (-hp- Model 11042A), a Micropotentiometer (Ballantine Model 440), and a DC Voltmeter (-hp- Model 3440A/3441A) are required for this check. Figure 5-4 describes test arrangement to be used.

NOTE

The micropotentiometer must have the proper radial resistance and current rating to deliver 0.30 v at its output.

b. Set UHF oscillator output to provide output to Model 410C reading recorded in Paragraph 5-25, step c, with .3 v input; frequency to 10 Mc. Record dc voltmeter reading for reference.

c. Vary VHF oscillator frequency from 10 MHz to 480 Mc maintaining reference dc voltmeter reading by readjusting VHF oscillator output. Model 410C reading should be the same as the reading set at 400 Hz in Paragraph 5-26, step d, ±2% at frequencies to 100 MHz and ±10% at all higher frequencies.

d. Replace VHF oscillator with UHF oscillator in Figure 5-4. Repeat steps b and c for UHF oscillator output frequencies from 480 MHz to 700 MHz.

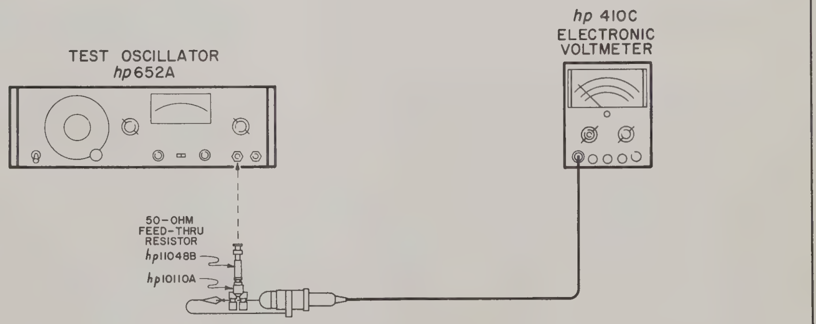


Figure 5-3. Low Frequency Response Test

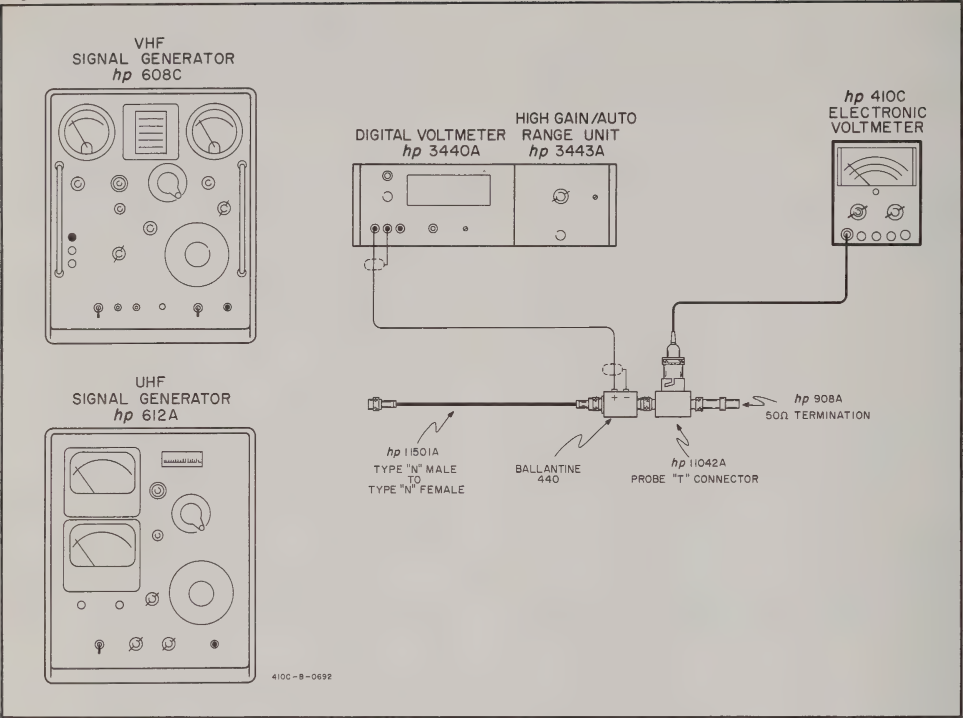


Figure 5-4. High Frequency Response Test

5-28. ADJUSTMENT AND CALIBRATION PROCEDURE.

5-29. The following is a complete adjustment and calibration procedure for the Model 410C. These operations should be conducted only if it has previously been established by Performance Checks, Paragraph 5-5, that the Model 410C is out of adjustment. Indiscriminate adjustment of the internal controls to "refine" settings may actually cause more difficulty. If the procedures outlined do not rectify any discrepancy that may exist, and all connections and settings have been rechecked, refer to Paragraph 5-41, Troubleshooting, for possible cause and recommended corrective action.

5-30. Remove top and bottom covers and two side panels; refer to Figure 5-5 throughout this procedure for location of adjustments.

5-31. CHOPPER FREQUENCY ADJUST.

a. A Voltmeter Calibrator (hp Model 738BR), an Electronic Counter (hp Model 5211A), and an AC Voltmeter (hp Model 3400A) will be required for this operation.

b. Use ac voltmeter to verify Model 410C line voltage of 115 v. Chopper frequency will vary with line voltage variations.

c. Connect Model 410C, electronic counter, and voltmeter calibrator as shown in Figure 5-6.

d. Set Model 410C FUNCTION SELECTOR to +DCV; RANGE to 1.5 V.

e. Adjust voltmeter calibrator to supply +5 v dc to the Model 410C.

f. Observe counter, and adjust A3R5 for a chopper frequency of 100 Hz (±2 Hz) if operated on a 60 Hz line. If operated on 50 Hz line, adjust A3R5 for a chopper frequency of 85 Hz (±2 Hz).

g. If line frequency is other than 50 or 60 Hz or if fine adjustment of chopper frequency is desired to minimize noise, connect ac voltmeter with RANGE for 0.01 V to Model 410C DC Amplifier OUTPUT.

h. Adjust A3R5 to give minimum voltage reading on ac voltmeter.

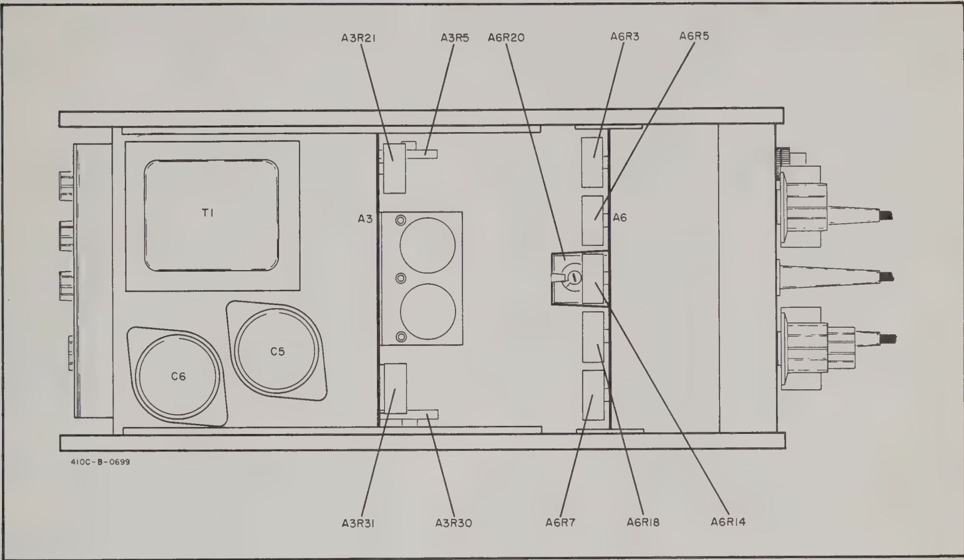


Figure 5-5. Adjustment Location

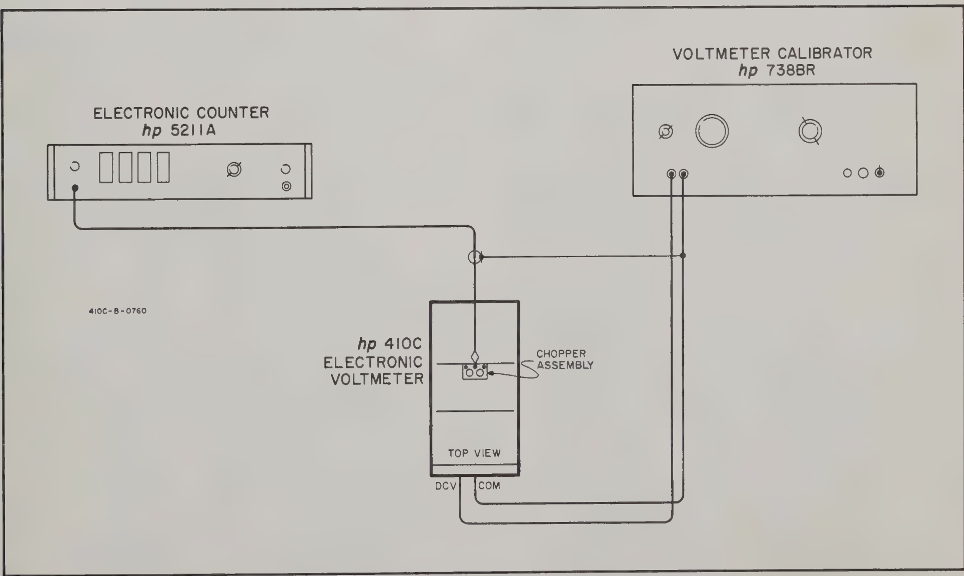


Figure 5-6. Chopper Frequency Adjust Setup

5-32. POWER SUPPLY CHECK.

a. Refer to Table 5-6 and Figure 5-8 for Power Supply check points and typical voltage values. Measure dc voltages between COM lead and designated location on A7.

Table 5-6. Power Supply Test

	Voltage	Location on A7 (Figure 5-8)	Tolerance
185	+175 V	903	±30 V
34	+38 V	Junction of CR6 and R4	±8.0 V
6	+6 V	926	±0.6 V
7.6	-9 V	Junction of CR7 and R7	±1.8 V

b. Measure +175 volt ac ripple across 903 and COM with ac voltmeter (hp Model 3400A). RMS value of ripple should not exceed 5.0 mv.

5-33. DC VOLTMETER CALIBRATION.

5-34. DC ZERO ADJUSTMENT AND BIAS.

a. Set Model 410C Function Selector to +DCV and Range Switch to 0.5 V.

b. Short DCV Cable to COM Cable.

c. Adjust A3R21 fully counterclockwise, then rotate about 20 degrees clockwise.

d. Adjust ZERO ADJ on rear panel for zero meter deflection. Switch to -DCV. If any deflection is observed, adjust ZERO ADJ to return meter pointer halfway back to zero. Check zero setting on all ranges for both +DCV and -DCV. Zero offset shall not exceed 1% in any case.

5-35. DC FULL SCALE ADJUST.

a. Connect Model 410C DCV and COM cables to Voltmeter Calibrator (hp Model 738BR) output terminals.

b. Set Model 410C FUNCTION SELECTOR to the +DCV position; RANGE switch to 0.015 V.

c. Adjust voltmeter calibrator to settings listed in Table 5-7.

d. Select proper A6R18 setting which will provide best overall full scale readings for 0.015 V, 0.05 V, and 0.15 V ranges. Adjust A3R30 for best overall full scale readings for ranges above 0.15 V.

NOTE

A6R18 must be adjusted before A3R30, because A6R18 affects all ranges and A3R30 only affects ranges above 0.15 V.

5-36. OHMMETER CALIBRATION.

a. Set Model 410C FUNCTION SELECTOR to OHMS; RANGE to RX10M.

b. Short OHMS and COM cables. Model 410C should read zero.

c. Vary Model 410C RANGE switch through remainder of OHMS settings. Meter should read zero, except at RX10 when meter should read about 0.1 ohms (resistance of leads).

d. Disconnect OHMS and COM cables. Set OHMS ADJ (rear panel) for ∞ reading. Check ∞ reading on all OHMS RANGE settings.

5-37. AMPLIFIER OUTPUT CALIBRATION.

a. A Voltmeter Calibrator (hp Model 738BR) and a DC Voltmeter (hp Model 3440A/3441A) is required for this calibration.

b. Set Model 410C FUNCTION SELECTOR to +DCV; RANGE to 5 V.

c. Adjust voltmeter calibrator to provide 5 V. Set dc voltmeter RANGE to 10 V.

d. Connect Model 410C DCV probe and COM lead to output of voltmeter calibrator. Connect dc voltmeter to dc amplifier OUTPUT on Model 410C rear panel.

e. Adjust A6R20 to give 1.5 v reading on dc voltmeter.

NOTE

Amplifier output will provide a negative voltage for all negative dc and ac inputs. The AC Probe is designed to provide a negative dc voltage to Model 410C.

Table 5-7. DCV Calibration Procedure

Model 410C Range Settings	Voltmeter Calibrator Settings Voltage	Model 410C Meter Readings	Adjustment
.015 V	.015	.0147 to .0153 V	A6R18
.05 V	.05	.049 to .051 V	A6R18
.15 V	.15	.147 to .153 V	A6R18
.5 V	.5	.49 to .51 V	A3R30
1.5 V	1.5	1.47 to 1.53 V	A3R30
5 V	5	4.9 to 5.1 V	A3R30
15 V	15	14.7 to 15.3 V	A3R30
50 V	50	49 to 51 V	A3R30
150 V	150	147 to 153 V	A3R30
500 V	300	290 to 310 V	A3R30
1500 V	300	270 to 330 V	A3R30

5-38. AC VOLTMETER CALIBRATION.

5-39. AC ZERO ADJUST.

a. Set Model 410C FUNCTION SELECTOR to ACV; RANGE to 0.5 V. Ensure full insertion of telephone plug from ac probe into Model 410C.

b. Set AC ZERO vernier on front panel to center of rotation.

c. Short Model 410C ac probe and ac probe common (short lead).

d. Adjust A3R31 for Model 410C approximately zero deflection.

e. Fine adjust AC ZERO vernier for Model 410C zero deflection.

5-40. AC FULL SCALE ADJUST.

CAUTION

WHEN MEASURING AC VOLTAGES, DO NOT PERMIT AC GROUND JUMPER OF MODEL 410C AC PROBE TO CONTACT UNGROUNDED SIDE OF AC SOURCE OR SERIOUS DAMAGE TO 410C WILL RESULT.

a. Connect Model 410C ac probe to voltmeter calibrator output terminals. Set Model 410C FUNCTION SELECTOR to ACV; RANGE to 0.5 V.

b. Adjust voltmeter calibrator to settings listed in Table 5-8 at 400 Hz rms output.

c. Adjust potentiometers called for under "Adjustment" to provide Model 410C readings listed.

Table 5-8. AC Full Scale Adjust

Model 410C Range	Voltmeter Calibrator AC Voltage Settings	Model 410C Reading ±3%	Adjustment
.5 V	.50	.5 V	A6R3
1.5 V	1.5	1.5 V	A6R5
5 V	5	5 V	A6R7
* 15 V	15	15 V	A6R14
* 50 V	50	50 V	A6R14
* 150 V	150	150 V	A6R14
* 500 V	300	300 V	A6R14

* A6R14 is proper adjustment of Model 410C for RANGE settings from 15 vac to 500 vac. Select proper A6R14 setting which will provide best overall results for these ranges.

5-41. TROUBLESHOOTING PROCEDURE.

5-42. This section contains procedures designed to assist in the isolation of malfunctions. These procedures are based on a systematic analysis of the instrument circuitry in an effort to localize the problem. These operations should be undertaken only after it has been established that the difficulty cannot be eliminated by the Adjustment and Calibration Procedures, Paragraph 5-28. An investigation should also be made to insure that the trouble is not a result of conditions external to the Model 410C.

5-43. Conduct a visual check of the Model 410C for possible burned or loose components, loose connections, or any other obvious conditions which might suggest a source of trouble.

5-44. Table 5-9 contains a summary of the front-panel symptoms that may be encountered. It should be used in initial efforts to select a starting point for troubleshooting operations.

5-45. Figure 5-7 contains procedures which may be used as a guide in isolating malfunctions.

5-46. The checks outlined in Figure 5-7 are not designed to measure all circuit parameters, rather only to localize the malfunction. Therefore, it is quite possible that additional measurements will be required to completely isolate the problem. Amplifier gain may also vary slightly between instruments; therefore it should not be necessary to precisely duplicate waveforms or values described.

5-47. Refer to Figure 5-10 for typical waveforms encountered in the Model 410C. Waveforms represent signals which occur when instrument is operating during overdriven conditions (0.5 vdc input to 0.015 v RANGE).

5-48. SERVICING ETCHED CIRCUIT BOARDS.

5-49. The ⓗⓟ Model 410C has three etched circuit boards. Use caution when removing them to avoid damaging mounted components. The ⓗⓟ Part Number for the assembly is silk screened on the interior of the circuit board to identify it. Refer to Section VI for parts replacement and ⓗⓟ Part Number information.

5-50. The etched circuit boards are a plated-through type. The electrical connection between sides of the board is made by a layer of metal plated through the component holes. When working on these boards, observe the following general rules.

a. Use a low-heat (25 to 50 watts) small-tip soldering iron, and a small diameter rosin core solder.

b. Circuit components can be removed by placing the soldering iron on the component lead on either side of the board, and pulling up on lead. If a component is obviously damaged, clip leads as close to component as possible and then remove. Excess heat can cause the circuit and board to separate, or cause damage to the component.

c. Component lead hole should be cleaned before inserting new lead.

d. To replace components, shape new leads and insert them in holes. Reheat with iron and add solder as required to insure a good electrical connection.

e. Clean excess flux from the connection and adjoining area.

f. To avoid surface contamination of the printed circuit, clean with weak solution of warm water and mild detergent after repair. Rinse thoroughly with clean water. When completely dry, spray lightly with Krylon (#1302 or equivalent).

Table 5-9. Front Panel Troubleshooting Procedure

FRONT PANEL SYMPTOM	POSSIBLE CAUSE
No meter deflection with input. ON - OFF lamp not glowing.	Check fuse (F1) on back panel.
In -DCV, pointer deflects 1/2 scale. In +DCV, pointer pegs downscale.	Check A3C5 (Figure 5-11).
In +DCV, pointer pegs downscale. In -DCV, pointer pegs upscale.	Check A3Q1, A3C6 or A3C12 (Figure 5-11).
Excessive jitter. Ohms function; all ranges except RX10M.	Check A2R2 (Figure 4-5).
*DCA mode out on 50 ma and 150 ma ranges.	Check A2R25 and A2R26 (Figure 4-3).
*If ∞ ADJ is effective in ranges from RX10 to RX1M, then shifts when RANGE switch is set to RX10M.	Check A2R2 (Figure 4-5).
*AC ZERO will not adjust properly. Pointer responds to input variations.	Check A1R5, A1R6, A1R7 and A3R31 (Figure 4-6).
*Operates in DCV mode on ranges 0.015 v to 0.15 v, but fails on higher ranges.	Check A2R2 and A3R30.
Dc amplifier output is +1.5 v. Meter will not deflect full scale in DCV or DCA mode.	Check A6R21, A6R20, A6R1, A6R18 and A6R17 (Figure 4-4).
*Meter pegs upscale on all ranges. +DC Amplifier output is high regardless of mode of operation.	Check for open resistor in amplifier feedback loop or shorted A1R10 (Figure 5-11).
In ACV mode, pointer will not deflect full scale with proper input applied.	Refer to Paragraph 5-38.
Operates on all ranges in ACV mode except 5 v ac position.	Check A6R16 and A6CR1 (Figure 4-6).
Instrument inoperative in all modes. Meter has slight random drift pattern.	Check chopper assembly. Connect 1 M ohm resistor across A3A1V1. If photocell were open, meter will now respond to input. Use 100 K resistor across A3A1V3 to check DC - Modulator (Figure 5-10).
Meter oscillates full scale at rate of 5 - 10 Hz.	Check chopper assembly. Connect 1 M ohm resistor across A3A1V2. If photocell were open, instrument will now respond to input. Use 100 K resistor across A3A1V2 to check DC - Modulator (Figure 5-10).
No ac zero.	Check C1 for short to chassis (Figure 4-6). Check ac probe.
No deflection on OHMS; dc ranges operative.	Check OHMS and DCA lead for short to common at alligator clip.
0.5 and 1.5 VAC range will not track.	Check A8V1 (Figure 5-13). Substitute known good ac probe.
5 VAC range will not track.	Check A6CR1.

* Refer to 6, Table 5-7.

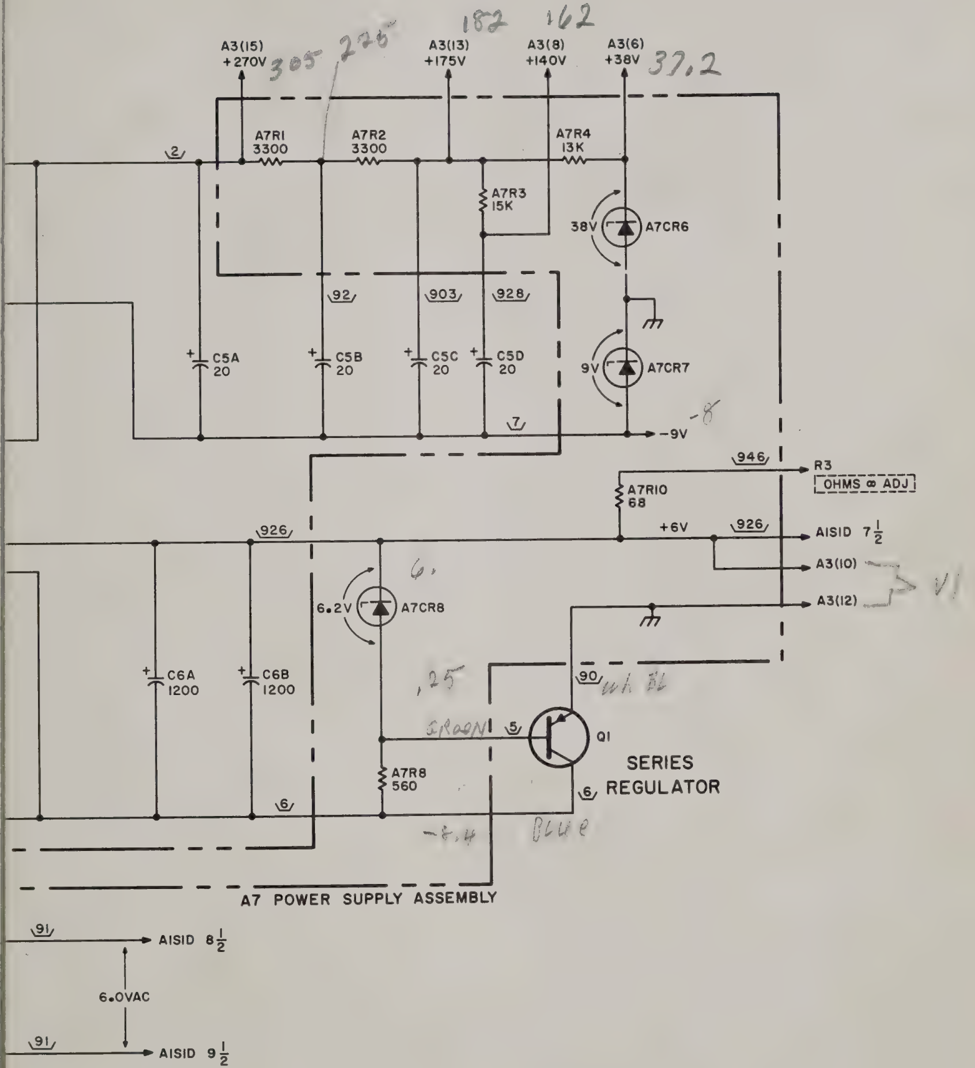


Figure 5-9. Power Supply Schematic

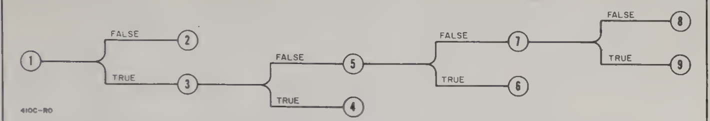
e. Clean excess flux from the connection and adjoining area.

f. To avoid surface contamination of the printed circuit, clean with weak solution of warm water and mild detergent after repair. Rinse thoroughly with clean water. When completely dry, spray lightly with Krylon (#1302 or equivalent).

Table 5-9. Front Panel Troubleshooting Procedure

FRONT PANEL SYMPTOM	POSSIBLE CAUSE
No meter deflection with input. ON - OFF lamp not glowing.	Check fuse (F1) on back panel.
In -DCV, pointer deflects 1/2 scale. In +DCV, pointer pegs downscale.	Check A3C5 (Figure 5-11).
In +DCV, pointer pegs downscale. In -DCV, pointer pegs upscale.	Check A3Q1, A3C6 or A3C12 (Figure 5-11).
Excessive jitter. Ohms function; all ranges except RX10M.	Check A2R2 (Figure 4-5).
*DCA mode out on 50 ma and 150 ma ranges.	Check A2R25 and A2R26 (Figure 4-3).
*If ∞ ADJ is effective in ranges from RX10 to RX1M, then shifts when RANGE switch is set to RX10M.	Check A2R2 (Figure 4-5).
*AC ZERO will not adjust properly. Pointer responds to input variations.	Check A1R5, A1R6, A1R7 and A3R31 (Figure 4-6).
*Operates in DCV mode on ranges 0.015 v to 0.15 v, but fails on higher ranges.	Check A2R2 and A3R30.
Dc amplifier output is +1.5 v. Meter will not deflect full scale in DCV or DCA mode.	Check A6R21, A6R20, A6R1, A6R18 and A6R17 (Figure 4-4).
*Meter pegs upscale on all ranges. +DC Amplifier output is high regardless of mode of operation.	Check for open resistor in amplifier feedback loop or shorted A1R10 (Figure 5-11).
In ACV mode, pointer will not deflect full scale with proper input applied.	Refer to Paragraph 5-38.
Operates on all ranges in ACV mode except 5 v ac position.	Check A6R16 and A6CR1 (Figure 4-6).
Instrument inoperative in all modes. Meter has slight random drift pattern.	Check chopper assembly. Connect 1 M ohm resistor across A3A1V1. If photocell were open, meter will now respond to input. Use 100 K resistor across A3A1V3 to check DC - Modulator (Figure 5-10).
Meter oscillates full scale at rate of 5 - 10 Hz.	Check chopper assembly. Connect 1 M ohm resistor across A3A1V2. If photocell were open, instrument will now respond to input. Use 100 K resistor across A3A1V2 to check DC - Modulator (Figure 5-10).
No ac zero.	Check C1 for short to chassis (Figure 4-6). Check ac probe.
No deflection on OHMS; dc ranges operative.	Check OHMS and DCA lead for short to common at alligator clip.
0.5 and 1.5 VAC range will not track.	Check A8V1 (Figure 5-13). Substitute known good ac probe.
5 VAC range will not track.	Check A6CR1.

* Refer to 6, Table 5-7.



(1) Check power supply voltage values using the procedure outlined in Paragraph 5-32. If voltages are correct, proceed to (3). If voltages are incorrect, proceed to (2).

(2) If malfunction appears in the power supply, and adjustment of the chopper frequency to 100 cps does not reduce the error, refer to Figure 5-8 for further investigation. Check voltage and resistance values listed with Model 410C FUNCTION +DCV; RANGE 0.015 v; INPUT +0.015 v. When deviation is noted, trace circuit investigating for faulty component.

(3) With Model 410C FUNCTION SELECTOR to -DCV; RANGE 0.015 v; overdrive with a +0.5 v input. Measure the dc voltage at the DC AMPLIFIER OUTPUT on Model 410C rear panel. Output should be approximately +4.0 v. If this measurement is correct, disconnect source and short DCV probe and COM lead. If output is zero, proceed to (5); if not, proceed to (4).

(4) Trace circuit from Pin 11, A3 to Pin 2, A6. Use ohmmeter to check values of A6R21, A6R20, A6R17 and A6R1. Refer to Figure 5-11 for pertinent component values. Check pertinent dc voltages under conditions listed in NOTE No. 4.

(5) Measure the dc voltage at Pin 1, A3. This voltage is typically 13-15 mv. If this voltage is correct, proceed to (7); if not, proceed to (6).

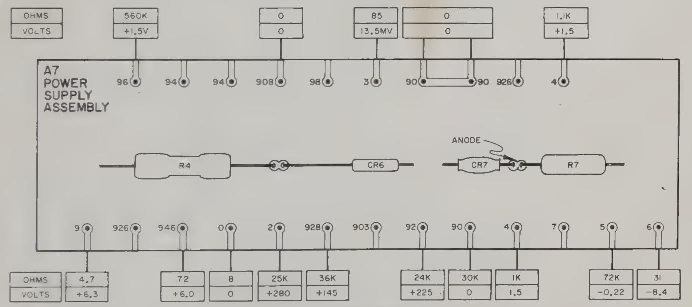
(6) Investigate switch circuit. Refer to asterisks in Table 5-9 for hints on how to troubleshoot switch circuit.

(7) Observe input voltage to demodulator (5) using an oscilloscope. Refer to Figure 5-10 for normal waveform under overdriven conditions specified. If waveform is normal, proceed to (9); if not, proceed to (8).

(8) Investigate the demodulator and cathode follower A1V3B. Refer to Figure 5-11 for typical voltage and parameter values under conditions listed in NOTE No. 4. Refer to Table 5-9 for method to check for open demodulator.

(9) Investigate the modulator and amplifier to include A1V1A, Q1 and Q2. Refer to Figure 5-11 for typical voltage and parameter values under conditions listed in NOTE No. 4. Refer to Table 5-9 for method to check for open modulator.

Figure 5-7. Troubleshooting Procedures



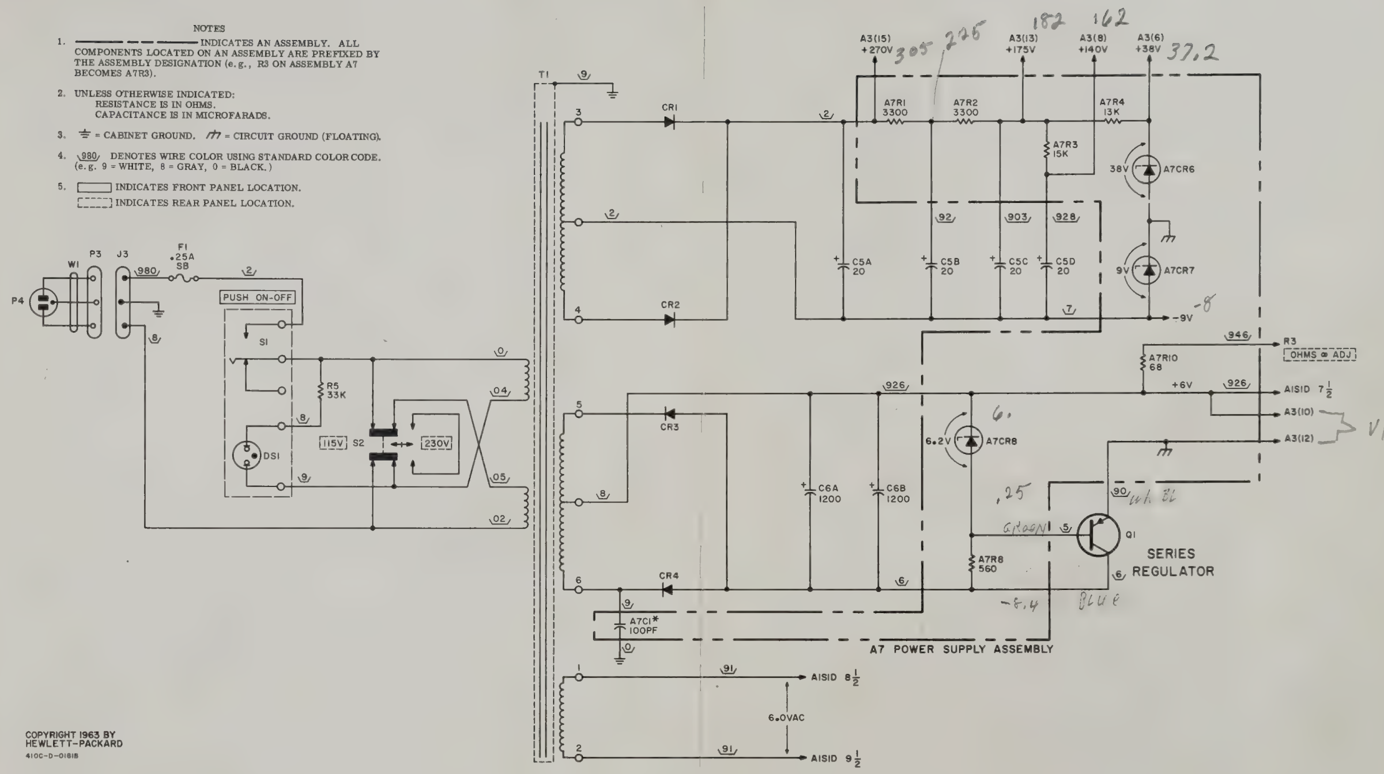
TEST CONDITIONS

VOLTAGE	RESISTANCE	NOTE
FUNCTION: +DCV RANGE: .015 V INPUT: +.015 V REFERENCE: Circuit ground	Instrument: OFF FUNCTION: +DCV RANGE: .015 V INPUT: DCV Shorted to COM	Voltage and resistance values listed are approximate values for a typical instrument. Deviations should be in the most significant figure before circuit tracing is warranted.

Figure 5-8. Power Supply Measurements

NOTES

1. ——— INDICATES AN ASSEMBLY. ALL COMPONENTS LOCATED ON AN ASSEMBLY ARE PREFIXED BY THE ASSEMBLY DESIGNATION (e.g., R3 ON ASSEMBLY A7 BECOMES A7R3).
2. UNLESS OTHERWISE INDICATED: RESISTANCE IS IN OHMS. CAPACITANCE IS IN MICROFARADS.
3. = CABINET GROUND. = CIRCUIT GROUND (FLOATING).
4. 980 DENOTES WIRE COLOR USING STANDARD COLOR CODE. (e.g. 9 = WHITE, 8 = GRAY, 0 = BLACK.)
5. INDICATES FRONT PANEL LOCATION. INDICATES REAR PANEL LOCATION.



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410C-D-01618

Figure 5-9. Power Supply Schematic

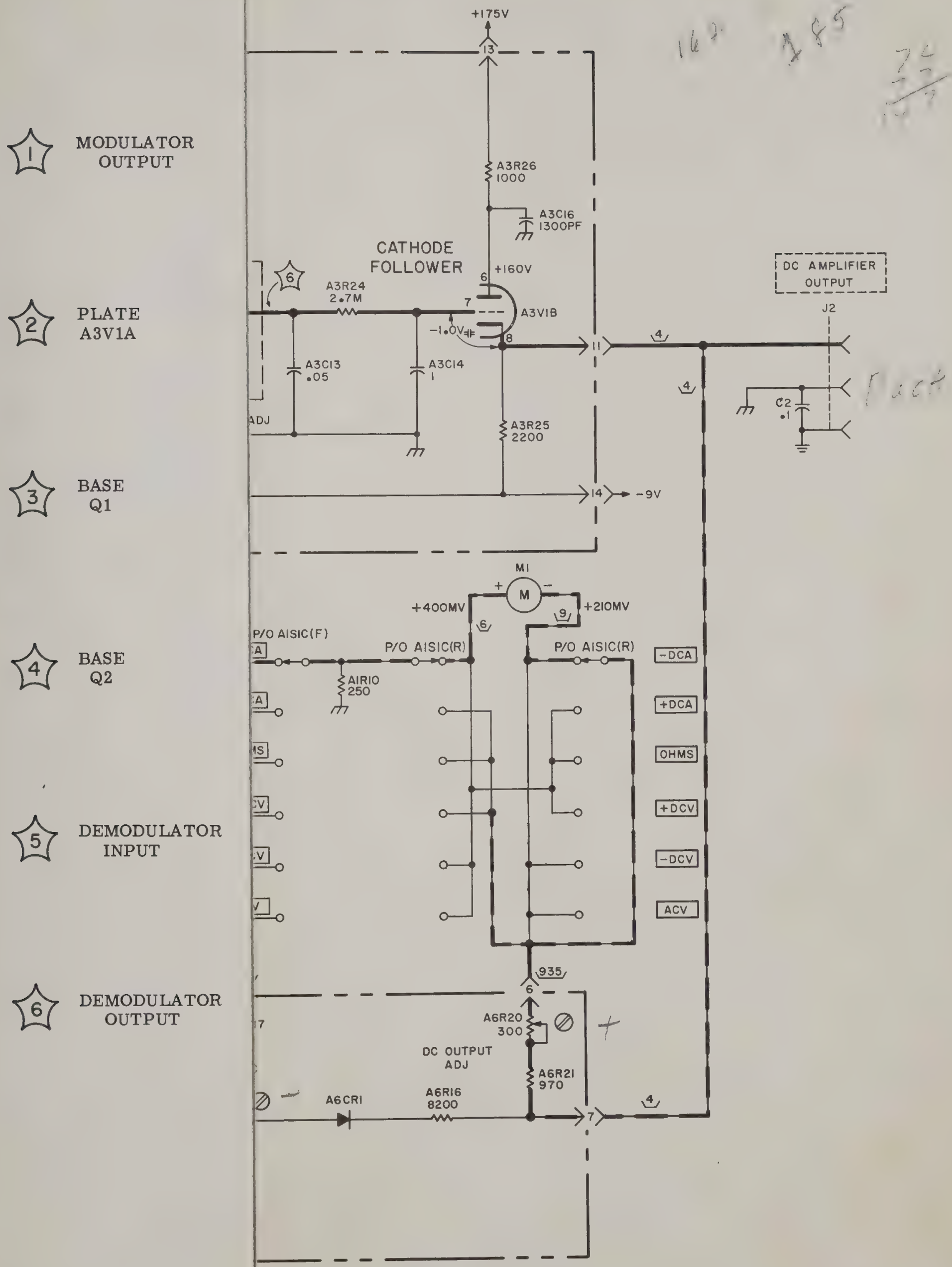


Figure 5-11. Amplifier Schematic

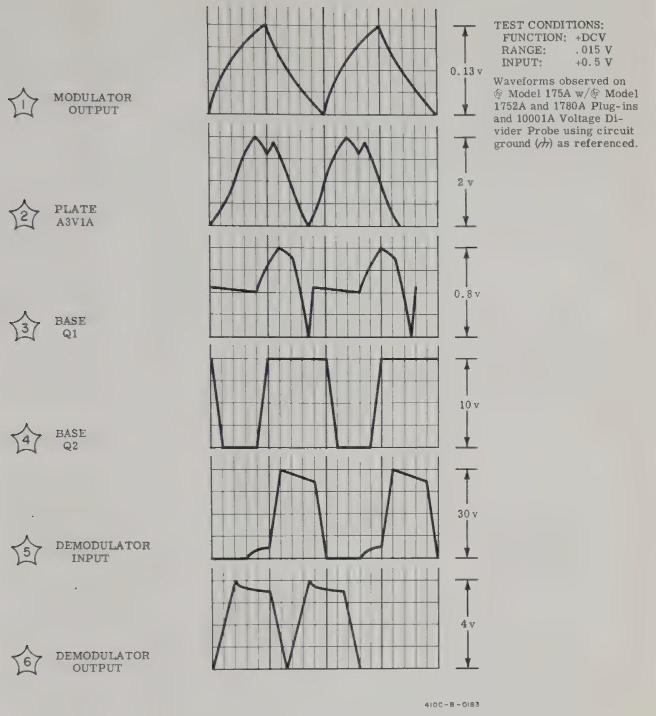


Figure 5-10. Typical Amplifier Waveforms

NOTES

1. A3A1V1 AND A3A1V3 ARE LIGHTED SIMULTANEOUSLY BY A3A1DS1, AND A3A1V2 AND A3A1V4 ARE LIGHTED BY A3A1DS2.
2. UNLESS OTHERWISE NOTED:
   RESISTANCE IS IN OHMS.
   CAPACITANCE IS IN MICROFARADS.
3. SWITCHES ARE SHOWN IN FULL CCW POSITIONS.
4. DC VOLTAGES SHOWN ARE TYPICAL UNDER THE FOLLOWING CONDITIONS:
   FUNCTION: +DCV
   RANGE: 1.5 V
   INPUT: +1.5 V
5. INDICATES AN ASSEMBLY. ALL COMPONENTS LOCATED ON AN ASSEMBLY ARE PREFIXED BY THE ASSEMBLY DESIGNATION (e.g., R3 ON ASSEMBLY A7 BECOMES A7R3.)
6. INDICATES SUBASSEMBLY.
7. INDICATES DC FEEDBACK.
8. P/O = PART OF.
9. INDICATES FRONT PANEL LOCATION.
   INDICATES REAR PANEL LOCATION.
10. INDICATES PANEL ADJUST.
    INDICATES SCREWDRIVER ADJUST.
11. = CABINET GROUND.
    = CIRCUIT GROUND (FLOATING).
12. \935/ DENOTES WIRE COLOR USING STANDARD COLOR CODE. (e.g. 9 = WHITE, 3 = ORANGE, 5 = GREEN.)
13. ✱ = OPTIMUM VALUE SELECTED AT FACTORY, AVERAGE VALUE SHOWN.
14. VOLTAGE IS DEPENDENT ON LOAD INTRODUCED BY EXTERNAL VOLTMETER.
15. VOLTAGE VARIES ACCORDING TO INDIVIDUAL TUBE.
16. PIN 8 IS REFERENCE. VOLTAGE VARIES ACCORDING TO INDIVIDUAL TUBE.

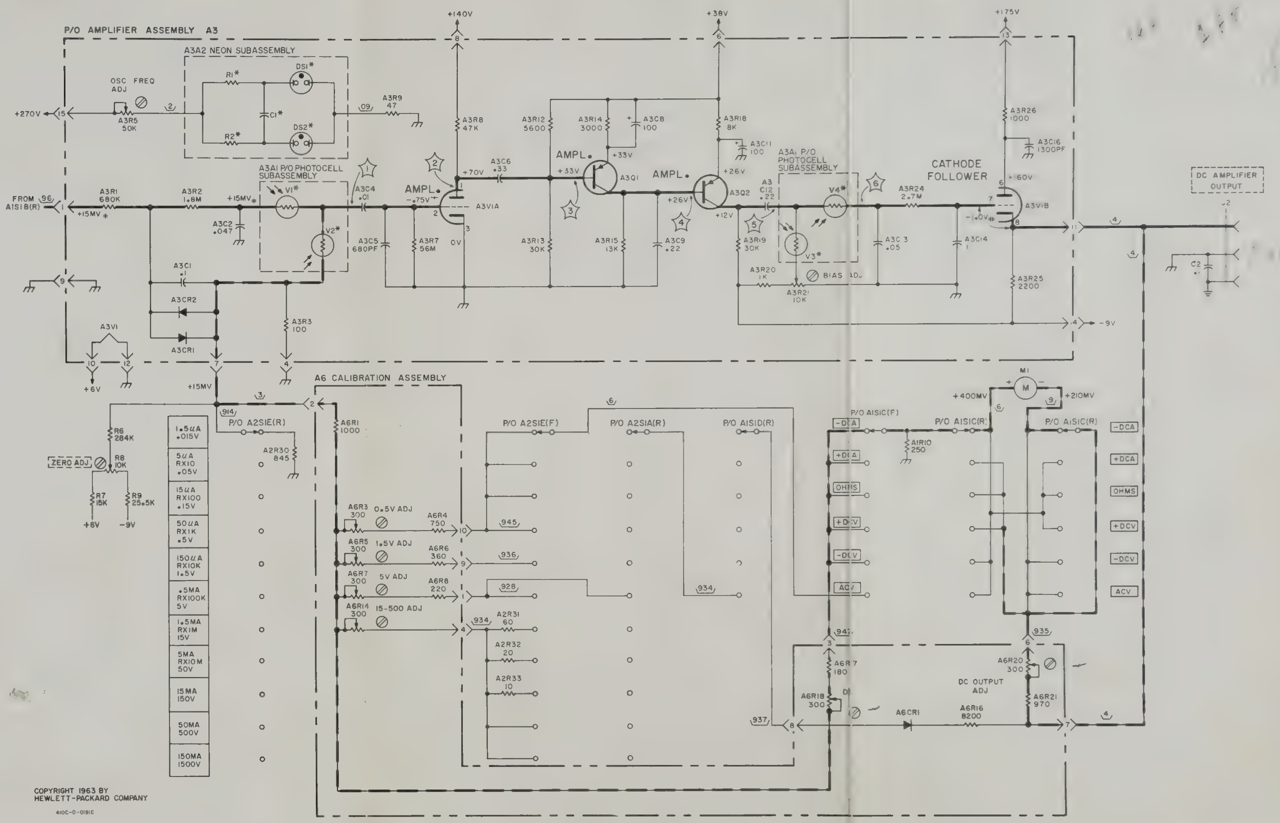


Figure 5-11. Amplifier Schematic

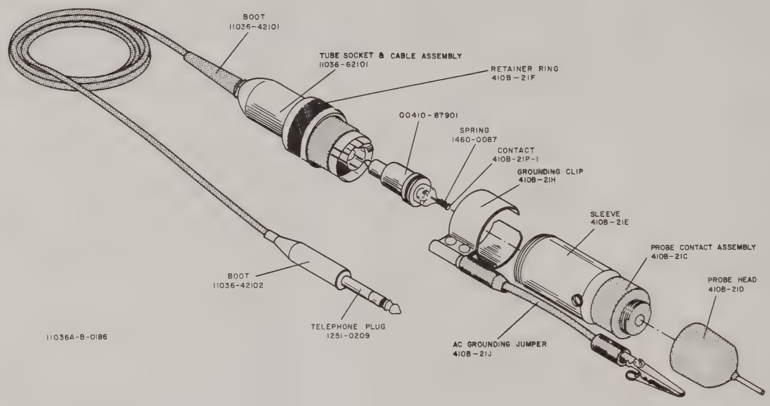
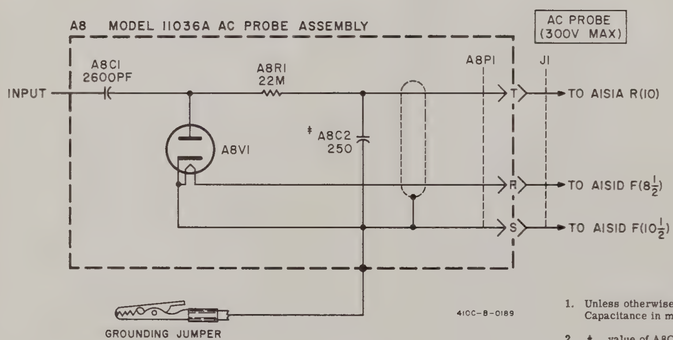


Figure 5-12. Model 11036A AC Probe (Exploded View)



NOTES

1. Unless otherwise specified, resistance in ohms. Capacitance in microfarads.
2. ‡ value of A8C2 includes probe lead capacity.
3. — — — indicates an assembly. All components located on any assembly are prefixed by the assembly designation (e.g. R1 on assembly A8 becomes A8R1).

Figure 5-13. Model 11036A AC Probe Schematic

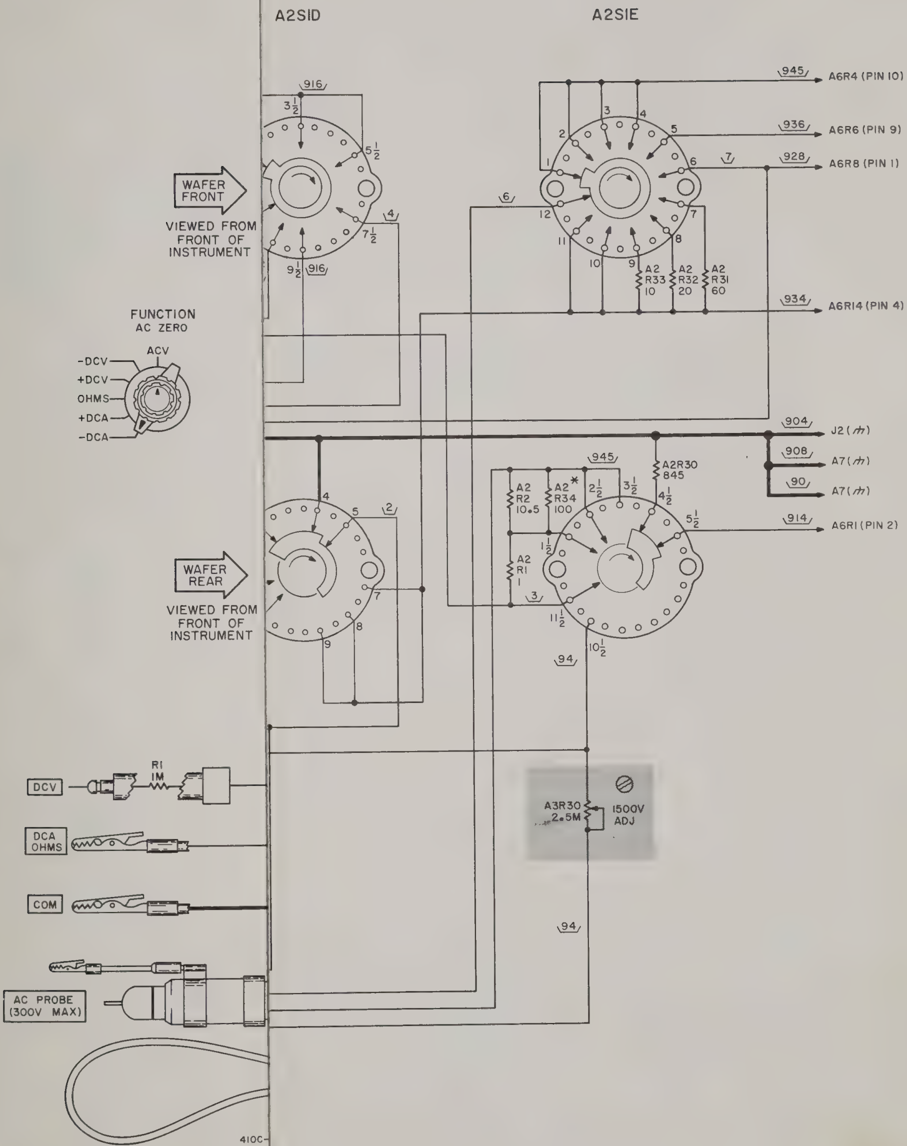


Figure 5-14. RANGE and FUNCTION Switching (Pictorial)

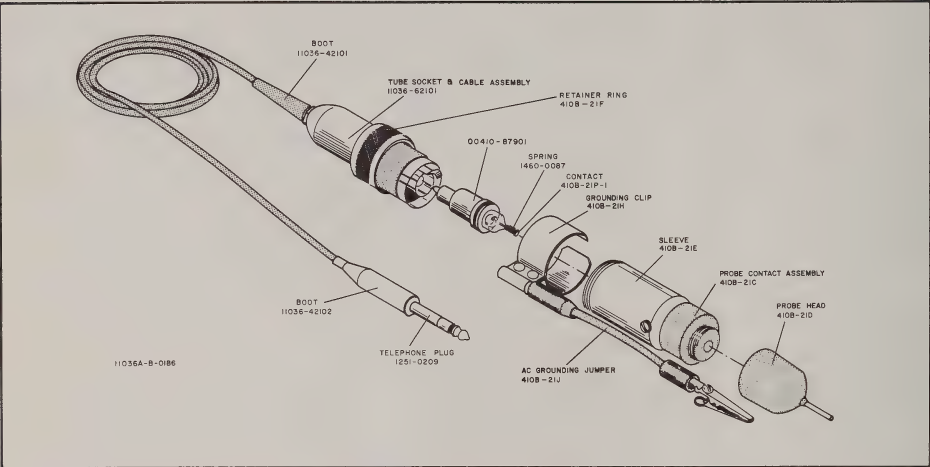
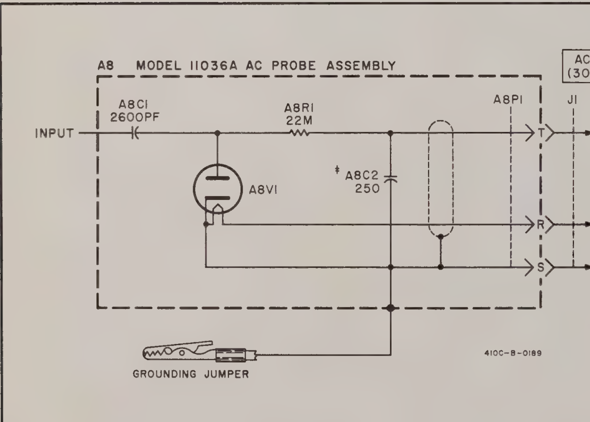


Figure 5-12. Model 11036A AC Probe (Exploded View)



NOTES

1. Unless otherwise specified, resistance in ohms. Capacitance in microfarads.
2. ‡ value of A8C2 includes probe lead capacity.
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Figure 5-13. Model 11036A AC Probe Schematic

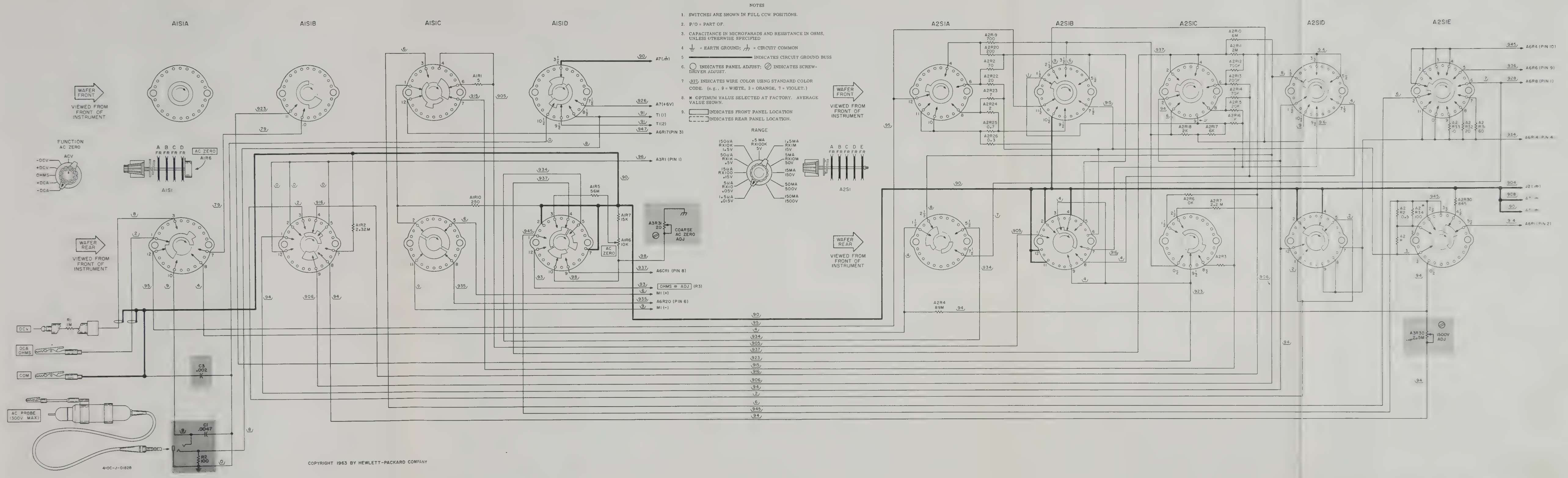

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Figure 5-14. RANGE and FUNCTION Switching (Pictorial)

Figure 5-15. Input RANGE and FUNCTION Switching Schematic

SECTION VI
REPLACEABLE PARTS

6-1. INTRODUCTION.

6-2. This section contains information for ordering replacement parts. Table 6-1 lists parts in alpha-numerical order of their reference designators and indicates the description and hp stock number of each part, together with any applicable notes. Table 6-2 lists parts in alpha-numerical order of their hp stock number and provides the following information on each part:

a. Description of the part (see list of abbreviations below).

b. Typical manufacturer of the part in a five-digit code (see list of manufacturers in Appendix).

c. Manufacturer's part number.

d. Total quantity used in the instrument (TQ column).

6-3. Replaceable hardware parts, not listed in Table 6-1 or 6-2, are listed in Table 6-3 in alphabetical order of description.

6-4. ORDERING INFORMATION.

6-5. To obtain replacement parts, address order or inquiry to your local Hewlett-Packard Field Office (see lists at rear of this manual for addresses). Identify parts by their Hewlett-Packard stock numbers.

6-6. NON-LISTED PARTS.

6-7. To obtain a part that is not listed, include:

a. Instrument model number.

b. Instrument serial number.

c. Description of the part.

d. Function and location of the part.

DESIGNATORS

A	= assembly
B	= motor
BT	= battery
C	= capacitor
CR	= diode
DL	= delay line
DS	= lamp
E	= misc electronic part
F	= fuse
FL	= filter
HR	= heater
IC	= integrated circuit
J	= jack
K	= relay
L	= inductor
M	= meter
MP	= mechanical part
P	= plug
Q	= transistor
QCR	= transistor-diode
R	= resistor
RT	= thermistor
S	= switch
T	= transformer
TC	= thermocouple
V	= vacuum tube, neon bulb, photocell, etc.
W	= cable
X	= socket
XDS	= lampholder
XF	= fuseholder
Z	= network

ABBREVIATIONS

Ag	= silver
Al	= aluminum
A	= ampere (s)
Au	= gold
C	= capacitor
cer	= ceramic
coef	= coefficient
com	= common
comp	= composition
conn	= connection
dep	= deposited
DPDT	= double-pole double-throw
DPST	= double-pole single-throw
elect	= electrolytic
encap	= encapsulated
F	= farad (s)
FET	= field effect transistor
fxd	= fixed
GaAs	= gallium arsenide
GHz	= gigahertz = 10^{+9} hertz
gd	= guard (ed)
Ge	= germanium
grd	= ground (ed)
H	= henry (ies)
Hg	= mercury
Hz	= hertz (cycle (s) per second)
ID	= inside diameter
impg	= impregnated
incd	= incandescent
ins	= insulation (ed)
kΩ	= kilohm (s) = 10^{+3} ohms
kHz	= kilohertz = 10^{+3} hertz
L	= inductor
lin	= linear taper
log	= logarithmic taper
m	= milli = 10^{-3}
mA	= milliampere (s) = 10^{-3} amperes
MHz	= megahertz = 10^{+6} hertz
MΩ	= megohm (s) = 10^{+6} ohms
met flm	= metal film
mfr	= manufacturer
mtg	= mounting
mV	= millivolt (s) = 10^{-3} volts
μ	= micro = 10^{-6}
μV	= microvolt (s) = 10^{-6} volts
my	= Mylar ®
nA	= nanoampere (s) = 10^{-9} amperes
NC	= normally closed
Ne	= neon
NO	= normally open
NPO	= negative positive zero (zero temperature coefficient)
ns	= nanosecond (s) = 10^{-9} seconds
nsr	= not separately replaceable
Ω	= ohm (s)
obd	= order by description
OD	= outside diameter
p	= peak
pc	= printed circuit
pF	= picofarad (s) = 10^{-12} farads
piv	= peak inverse voltage
p/o	= part of
pos	= position (s)
poly	= polystyrene
pot	= potentiometer
p-p	= peak-to-peak
ppm	= parts per million
prec	= precision (temperature coefficient, long term stability, and/or tolerance)
R	= resistor
Rh	= rhodium
rms	= root-mean-square
rot	= rotary
Se	= selenium
sect	= section (s)
Si	= silicon
sl	= slide
SPDT	= single-pole double-throw
SPST	= single-pole single-throw
Ta	= tantalum
TC	= temperature coefficient
TiO_2	= titanium dioxide
tog	= toggle
tol	= tolerance
trim	= trimmer
TSTR	= transistor
V	= volt (s)
vacw	= alternating current working voltage
var	= variable
vdcw	= direct current working voltage
W	= watt (s)
w/	= with
wiv	= working inverse voltage
w/o	= without
ww	= wirewound
*	= optimum value selected at factory, average value shown (part may be omitted)
**	= no standard type number assigned (selected or special type)

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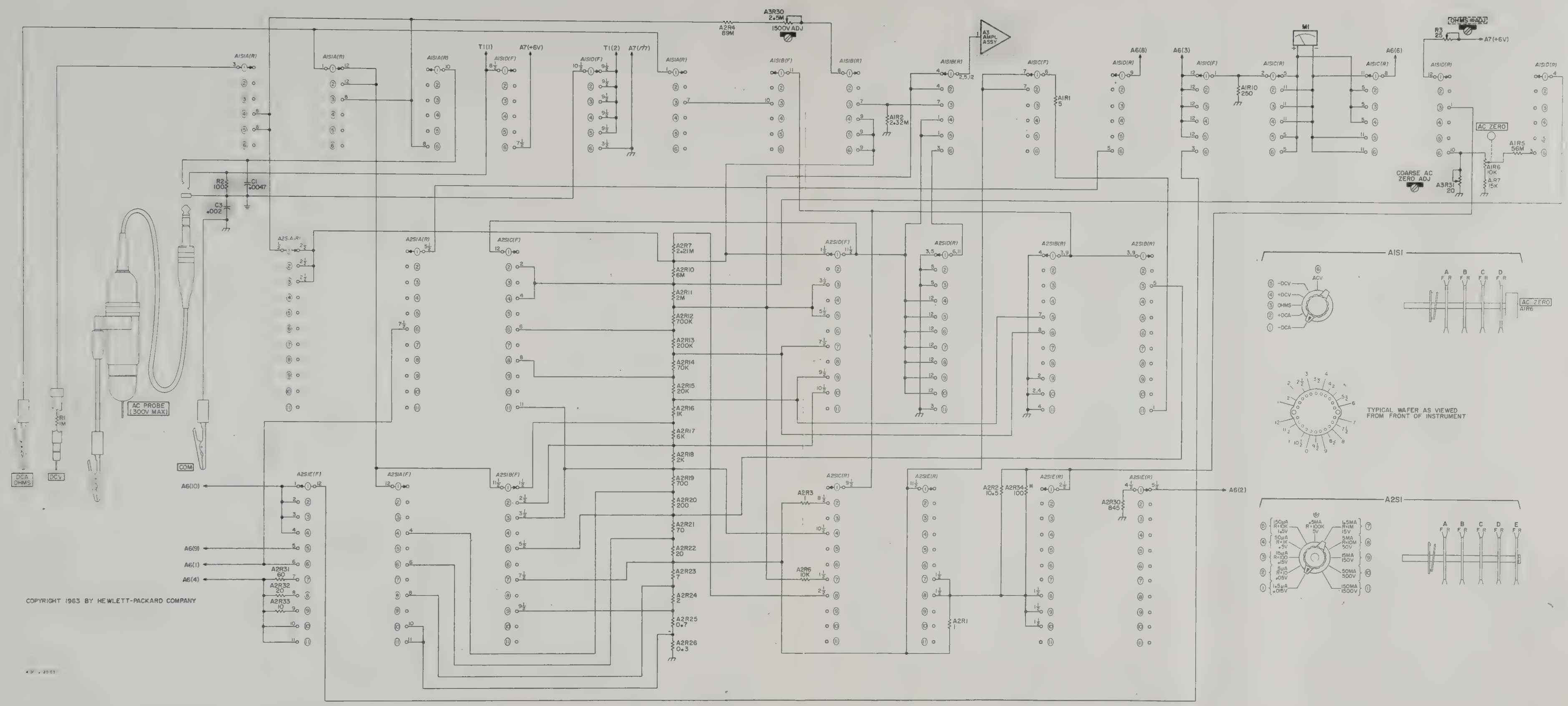

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Figure 5-15. Input RANGE and FUNCTION Switching Schematic

SECTION VI
REPLACEABLE PARTS

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DESIGNATORS

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C	= capacitor
CR	= diode
DL	= delay line
DS	= lamp
E	= misc electronic part
F	= fuse
FL	= filter
HR	= heater
IC	= integrated circuit
J	= jack
K	= relay
L	= inductor
M	= meter
MP	= mechanical part
P	= plug
Q	= transistor
QCR	= transistor-diode
R	= resistor
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T	= transformer
TC	= thermocouple
V	= vacuum tube, neon bulb, photocell, etc.
W	= cable
X	= socket
XDS	= lampholder
XF	= fuseholder
Z	= network

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Al	= aluminum
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Au	= gold
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cer	= ceramic
coef	= coefficient
com	= common
comp	= composition
conn	= connection
dep	= deposited
DPDT	= double-pole double-throw
DPST	= double-pole single-throw
elect	= electrolytic
encap	= encapsulated
F	= farad (s)
FET	= field effect transistor
fxd	= fixed
GaAs	= gallium arsenide
GHz	= gigahertz = 10^{+9} hertz
gd	= guard (ed)
Ge	= germanium
grd	= ground (ed)
H	= henry (ies)
Hg	= mercury
Hz	= hertz (cycle (s) per second)
ID	= inside diameter
impg	= impregnated
incd	= incandescent
ins	= insulation (ed)
kΩ	= kilohm (s) = 10^{+3} ohms
kHz	= kilohertz = 10^{+3} hertz
L	= inductor
lin	= linear taper
log	= logarithmic taper
m	= milli = 10^{-3}
mA	= milliampere (s) = 10^{-3} amperes
MHz	= megahertz = 10^{+6} hertz
MΩ	= megohm (s) = 10^{+6} ohms
met flm	= metal film
mfr	= manufacturer
mtg	= mounting
mV	= millivolt (s) = 10^{-3} volts
μ	= micro = 10^{-6}
μV	= microvolt (s) = 10^{-6} volts
my	= Mylar ®
nA	= nanoampere (s) = 10^{-9} amperes
NC	= normally closed
Ne	= neon
NO	= normally open
NPO	= negative positive zero (zero temperature coefficient)
ns	= nanosecond (s) = 10^{-9} seconds
nsr	= not separately replaceable
Ω	= ohm (s)
obd	= order by description
OD	= outside diameter
p	= peak
pc	= printed circuit
pF	= picofarad (s) = 10^{-12} farads
piv	= peak inverse voltage
p/o	= part of
pos	= position (s)
poly	= polystyrene
pot	= potentiometer
p-p	= peak-to-peak
ppm	= parts per million
prec	= precision (temperature coefficient, long term stability, and/or tolerance)
R	= resistor
Rh	= rhodium
rms	= root-mean-square
rot	= rotary
Se	= selenium
sect	= section (s)
Si	= silicon
sl	= slide
SPDT	= single-pole double-throw
SPST	= single-pole single-throw
Ta	= tantalum
TC	= temperature coefficient
TiO_2	= titanium dioxide
tog	= toggle
tol	= tolerance
trim	= trimmer
TSTR	= transistor
V	= volt (s)
vacw	= alternating current working voltage
var	= variable
vdcw	= direct current working voltage
W	= watt (s)
w/	= with
wiv	= working inverse voltage
w/o	= without
ww	= wirewound
*	= optimum value selected at factory, average value shown (part may be omitted)
**	= no standard type number assigned (selected or special type)

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REV G

Table 6-1. Replaceable Parts

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A1	410C-19B			Switch Assembly: Selector	-hp-	
R1	0727-0004		1	R: fxd C flm 5 Ω ±1% 1/2 W	94459	CVS
R2	0727-0480		1	R: fxd C flm 2.32 MΩ ±1% 0.5 W	94459	CVF
R3, R4				Not assigned		
R5	0687-5661		2	R: fxd comp 56 MΩ ±10% 1/2 W	01121	EB5661
R6	2100-0389		1	R: var ww lin 10 kΩ ±10% 5 W	-hp-	
R7	0687-1531		1	R: fxd comp 15 kΩ ±10% 1/2 W	01121	EB1531
R8, R9				Not assigned		
R10	0727-0479		1	R: fxd C flm 250 Ω ±1% 1/2 W	94459	CVF
S1	3100-0383		1	Switch: rotary 4-section 6-position (FUNCTION)	76854	obd
A2	410C-19A			Switch Assembly: Range	-hp-	
R1	0728-0004		2	R: fxd C flm 1 Ω ±1% 1/2 W	94459	CVF
R2	0727-0955		1	R: fxd C flm 10.5 Ω ±1% 1/2 W	94459	CVF
R3	0728-0004			R: fxd C flm 1 Ω ±1% 1/2 W	94459	CVF
R4	0733-0018		1	R: fxd C flm 89 MΩ ±1% 2 W	03888	HV2000
R5				Not assigned		
R6	0687-1031		1	R: fxd comp 10 kΩ ±10% 1/2 W	01121	EB1031
R7	0727-0478		1	R: fxd C flm 2.21 MΩ ±1% 1/2 W	94459	CVF
R8, R9				Not assigned		
R10	0730-0176		1	R: fxd 6 MΩ ±0.5% 1 W	94459	CVC
R11	0727-0459		1	R: fxd C flm 2 MΩ ±0.5% 1 W	01295	CD1R
R12	0727-0458		1	R: fxd C flm 700 kΩ ±0.5% 1/2 W	94459	CVF
R13	0727-0457		1	R: fxd C flm 200 kΩ ±1% 1/2 W	94459	CVF
R14	0727-0456		1	R: fxd C flm 70 kΩ ±0.5% 1/2 W	94459	CVF
R15	0727-0455		1	R: fxd C flm 20 kΩ ±0.5% 1/2 W	94459	CVF
R16	0727-0451		1	R: fxd C flm 1000 Ω ±0.5% 1/2 W	94459	CVF
R17	0727-0454		1	R: fxd C flm 6000 Ω ±0.5% 1/2 W	94459	CVF
R18	0727-0453		1	R: fxd C flm 2000 Ω ±0.5% 1/2 W	94459	CVF
R19	0727-0452		1	R: fxd C flm 700 Ω ±0.5% 1/2 W	94459	CVF
R20	0727-0450		1	R: fxd C flm 200 Ω ±0.5% 1/2 W	94459	CVF
R21	0727-0449		1	R: fxd C flm 70 Ω ±1% 1/2 W	94459	CVF
R22	0727-0448		2	R: fxd C flm 20 Ω ±1% 1/2 W	94459	CVF
R23	0727-0446		1	R: fxd C flm 7 Ω ±1% 1/2 W	94459	CVS
R24	0727-0445		1	R: fxd C flm 2 Ω ±1% 1/2 W	94459	CVS
R25	410C-26B		1	R: fxd 0.7 Ω	-hp-	
R26	410C-26A		1	R: fxd 0.3 Ω	-hp-	
R27 thru R29				Not assigned		
R30	0727-0701		1	R: fxd C flm 845 Ω ±1% 1/2 W	94459	CVF
R31	0727-0031		1	R: fxd C flm 60 Ω ±1% 1/2 W	01295	DC1/2PR
R32	0727-0448			R: fxd C flm 20 Ω ±1% 1/2 W	94459	CVF
R33	0727-0948		1	R: fxd C flm 10 Ω ±1% 1/2 W	94459	CVF
R34*	0687-1011		1	R: fxd comp 100 Ω ±10% 1/2 W	01121	EB1011
S1	3100-0382		1	Switch: rotary 5-section 11-position (RANGE)		
A3	410C-65A			Assembly: Amplifier	-hp-	
A1	1990-0020			Assembly: Chopper Block	-hp-	
V1 thru V4				Not separately replaceable, part of Chopper Assembly (1990-0020)		

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A3 (Cont'd)						
A2	1990-0207			Assembly: Lamp	-hp-	
C1				Not separately replaceable, part of Lamp Assembly (1990-0207)		
DS1, DS2				Not separately replaceable, part of Lamp Assembly (1990-0207)		
R1, R2				Not separately replaceable, part of Lamp Assembly (1990-0207)		
C1	0160-2641		1	C: fxd poly 0.1 μF ±10% 50 vdcw	56289	P136072
C2	0160-3116		1	C: fxd poly 0.047 μF ±10% 50 vdcw	56289	P136049
C3				Not assigned		
C4	0160-0161		1	C: fxd my 0.01 μF 200 vdcw	56289	192P10392
C5	0140-0208		1	C: fxd mica 680 pF ±5% 300 vdcw	00853	obd
C6	0160-2128		1	C: fxd my 0.33 μF ±20% 200 vdcw	72354	F307C334M
C7				Not assigned		
C8	0180-0039		1	C: fxd Al elect 100 μF 12 vdcw	56289	D32697
C9	0160-3366		2	C: fxd my 0.22 μF ±20% 100 vdcw	72354	F307C224M
C10				Not assigned		
C11	0180-1819		1	C: fxd Al elect 100 μF 50 vdcw	56289	30D107G0500H2
C12	0160-3366			C: fxd my 0.22 μF ±20% 100 vdcw	72354	F307C224M
C13	0150-0096		1	C: fxd cer 0.05 μF 100 vdcw	72982	845-X5V-5032
C14	0170-0018		1	C: fxd my 1 μF ±5% 200 vdcw	84411	HEW-4
C15				Not assigned		
C16	0140-0154		1	C: fxd mica 1300 pF ±5% 500 vdcw	14655	RCM15E101K
CR1, CR2	1901-0156		1	Diode: Si 50 mA	03877	SG3288
Q1	1850-0013		1	TSTR: Ge PNP	86684	CP2366
Q2	1850-0040	102	1	TSTR: Ge PNP	04713	SA591
R1	0687-6841	E'G	1	R: fxd comp 680 kΩ ±10% 1/2 W	01121	EB6841
R2	0687-1851			R: fxd comp 1.8 MΩ ±10% 1/2 W	01121	EB1851
R3	0811-0998		1	R: fxd comp 100 Ω ±1% 1/4 W	-hp-	
R4				Not assigned		
R5	2100-0760		1	R: var comp lin 50 kΩ ±30% 1/4 W	71590	Series 5 Type 70-1
R6				Not assigned		
R7	0687-5661			R: fxd comp 56 MΩ ±10% 1/2 W	01121	EB5661
R8	0687-4731		1	R: fxd comp 47 kΩ ±10% 1/2 W	01121	EB4731
R9	0687-4701		1	R: fxd comp 47 Ω ±10% 1/2 W	01121	EB4701
R10, R11				Not assigned		
R12	0757-0164		1	R: fxd met flm 5600 Ω ±2% 1/2 W	07115	C20
R13	0757-0166		2	R: fxd met flm 30 kΩ ±2% 1/2 W	07115	C20
R14	0757-0163		1	R: fxd met flm 3000 Ω ±2% 1/2 W	07115	C20
R15	0757-0165		1	R: fxd met flm 13 kΩ ±2% 1/2 W	07115	C20
R16, R17				Not assigned		
R18	0757-0091		1	R: fxd met flm 18 kΩ ±2% 1/2 W	07115	C20
R19	0757-0166			R: fxd met flm 30 kΩ ±2% 1/2 W	07115	C20
R20	0687-1021		3	R: fxd comp 1000 Ω ±10% 1/2 W	01121	EB1021
R21	2100-0396		1	R: var ww lin 10 kΩ ±20% 1 W	79727	E870PAB
R22, R23				Not assigned		
R24	0687-2751		1	R: fxd 2.7 MΩ ±10% 1/2 W	01121	EB2751
R25	0687-2221		1	R: fxd comp 2.2 kΩ ±10% 1/2 W	01121	EB2221
R26	0687-1021			R: fxd comp 1000 Ω ±10% 1/2 W	01121	EB1021
R27 thru R29				Not assigned		
R30	2100-0413		1	R: var comp lin 2.5 MΩ ±20% 1/4 W	71590	Series 5 Type 70-1

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A3 (Cont'd)						
R31	2100-0227		1	R: var ww lin 20 Ω ±10% 1 W	-hp-	
V1	1932-0027		1	Tube: electron 12AT7 dual triode	80131	12AT7
A4, A5				Not assigned		
A6	410C-65B			Assembly: Calibration	-hp-	
CR1	1901-0025		1	Diode: Si 50 mA	93332	D3C72
R1	0727-0751		1	R: fxd C flm 1000 Ω ±1% 1/2 W	94459	CVF
R2				Not assigned		
R3	2100-0394		6	R: var ww lin 300 Ω ±20% 1 W	11236	Series 110
R4	0727-0747		2	R: fxd C flm 750 Ω ±1% 1/2 W	94459	CVF
R5	2100-0394			R: var ww lin 300 Ω ±20% 1 W	11236	Series 110
R6	0728-0011		1	R: fxd C flm 360 Ω ±1% 1/2 W	94459	CVF
R7	2100-0394			R: var ww lin 300 Ω ±20% 1 W	11236	Series 110
R8	0728-0010		1	R: fxd C flm 220 Ω ±1% 1/2 W	94459	CVS
R9 thru R13				Not assigned		
R14	2100-0394			R: var ww lin 300 Ω ±20% 1 W	11236	Series 110
R15				Not assigned		
R16	0758-0048		1	R: fxd met flm 8200 Ω ±5% 1/2 W	07115	C20
R17	0727-0866		1	R: fxd C flm 180 Ω ±1% 1/2 W	94459	CVF
R18	2100-0394			R: var ww lin 300 Ω ±20% 1 W	11236	Series 110
R19				Not assigned		
R20	2100-0395		1	R: var comp lin 300 Ω ±20% 1/4 W	71590	Series 5 Type 70-1
R21	0727-0475		1	R: fxd C 970 Ω ±0.5% 1/2 W	94459	CD1/2MR
A7	410C-65C			Assembly: Power Supply	-hp-	
C1*	0140-0041		1	C: fxd mica 100 pF ±5% 500 vdcw	04062	RCM15E101J
CR1 thru CR5				Not assigned		
CR6	1902-0026		1	Diode: breakdown 36.5 V ±10% 0.4 W	04713	SZ10939-343
CR7	1902-0567		1	Diode: breakdown 9.09 V ±10% 500 mW	59875	PS18256A
CR8	1902-0049		1	Diode: breakdown 6.19 V ±5% 0.4 W	04713	SZ10939-122
R1, R2	0764-0003		2	R: fxd met flm 3300 Ω ±5% 2 W	07115	C42S
R3	0758-0018		1	R: fxd met flm 15 kΩ ±5% 1/2 W	07115	C20
R4	0764-0026		1	R: fxd met flm 13 kΩ ±5% 2 W	07115	C42S
R5, R6				Not assigned		
R7				Deleted in serial number 844-09954 and up		
R8	0758-0002		1	R: fxd met flm 560 Ω ±5% 1/2 W	07115	C20
R9				Not assigned		
R10	0758-0083		1	R: fxd met flm 68 Ω ±5% 1/2 W	07115	C20
A8	11036A			Assembly: AC Probe (-hp- Model 11036A, complete)	-hp-	
C1				Not separately replaceable, part of AC Probe (11036A)		
C2				Not separately replaceable, part of AC Probe (11036A)		
P1	1251-0209		1	Plug: telephone 3 conductor	82389	2P-1297

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A8 (Cont'd)						
R1				Not separately replaceable, part of AC Probe (11036A)		
V1	00410-87901			Tube: electron diode	-hp-	
C1	0170-0021		1	C: fxd my 4700 pF ±10% 400 vdcw	84411	620SJ0047
C2	0170-0022		1	C: fxd my 0.1 μF ±10% 600 vdcw	59875	HEW-17
C3	0150-0023		1	C: fxd cer 2000 pF ±20% 1000 vdcw	56289	19C203A
C4				Not assigned		
C5	0180-0025		1	C: fxd Al elect 4x20 μF +50% -10% 450 vdcw	00853	Type PLI
C6	0180-0153		1	C: fxd Al elect 2x1200 μF +100% -10% 20 vdcw	00853	4S4039
CR1, CR2	1901-0036		1	Diode: Si 300 mA	01841	obd
CR3, CR4	1901-0049		1	Diode: Si 500 mA	86684	34934
DS1	2140-0244		1	Light indicator: A1H neon (p/o S3)	87034	A1H
F1	2110-0018		1	Fuse: cartridge slow-blow 0.25 A 125 V	71400	MDL1/4
J1	1251-0200		1	Jack: telephone 3 conductor	82389	3J-1291
J2				Assembly: DC AMPLIFIER OUTPUT (see MISCELLANEOUS for Part Nos.		
J3	1251-0148		1	Connector: power cord receptacle	82389	AC3G
M1	1120-0317		1	Meter: 0-1 mA	-hp-	
Q1	1850-0098		1	TSTR: Ge PNP	83298	B-1493
R1	0727-0274		1	R: fxd C flm 1 MΩ ±1% 1/2 W	94459	CVF
R2	0758-0086		1	R: fxd met flm 100 Ω ±5% 1/4 W	07115	C07
R3	2100-0415		1	R: var ww lin 25 Ω ±10% 2 W	08984	FFF-1
R4				Not assigned		
R5	0687-3331		1	R: fxd comp 33 kΩ ±10% 1/2 W	01121	EB3331
R6	0727-0231		1	R: fxd C flm 284 kΩ ±0.5% 1/2 W	91637	DCS1/2
R7	0727-0168		1	R: fxd C flm 15 kΩ ±1% 1/2 W	91637	DCS1/2-15
R8	2100-1567		1	R: var ww 10 kΩ ±10% 2 W	11236	117
R9	0727-0180		1	R: fxd C flm 25.5 kΩ ±1% 1/2 W	91637	DCS1/2-15
S1	3101-0100		1	Switch: SPST pushbutton	87034	SW-624-109
S2	3101-0033		1	Switch: DPDT slide	79727	G-326 6510
T1	9100-0174		1	Transformer: power	-hp-	
W1	8120-0078		1	Cable: power 3 conductor 7-1/2 ft. long w/NEMA plug	70903	KH-4147
XQ1	1200-0044		1	Socket: transistor TO-3	97913	M7(PB)
				MISCELLANEOUS		
	1220-0066		1	Shield: tube	82252	319A-2
	1490-0088		1	Clip: ground	71785	422-11-11-095
	1510-0006		1	Binding post: black (p/o J2)	-hp-	
	1510-0007		2	Binding post: red (p/o J2)	-hp-	

Table 6-2. Replaceable Hardware

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
	11036-42102		1	Boot: AC plug (p/o 11036A)	-hp-	
	11036-42101		1	Boot: AC probe (p/o 11036A)	-hp-	
	412A-83A		3	Boot: cable	-hp-	
	410C-12A		1	Bracket: connector (used with A3 connector)	-hp-	
	410C-12B		1	Bracket: switch (used with A6 connector)	-hp-	
	00410-01202		2	Bracket: cover retainer	-hp-	
	1200-0081		2	Bushing: insulator (used with Q1)	26365	974 Special
	1410-0091		2	Bushing: panel (used with A1S1 and A2S2)	28520	SB-437-4
	0400-0019		3	Bushing: strain relief	-hp-	
	410C-1A		1	Chassis: transformer	-hp-	
	410B-21H		1	Clip: grounding (p/o 11036A)	-hp-	
	1251-0195		1	Connector: 10 pin P.C.	02660	143-010-09 (109)
	1251-0213		1	Connector: 15 pin P.C.	95354	SD-615W (125)
	410B-21P		1	Contact: Diode (p/o 11036A)	-hp-	
	3130-0038		1	Coupler: switch	45255	10X20X1
	5000-0703		1	Cover: side	-hp-	
	00410-64102		1	Cover: top (requires 2 brackets 00410-01202)	-hp-	
	5060-0714		1	Cover: bottom	-hp-	
	5060-0727		2	Foot assembly	-hp-	
	5060-0703		2	Frame: side	-hp-	
	410B-21J		1	Ground lead assembly (p/o 11036A)	-hp-	
	5040-0700		2	Hinge (used with tilt stand)	-hp-	
	1400-0084		1	Holder: fuse	75915	342014
	0340-0086		1	Insulator: binding post double	-hp-	
	0340-0091		1	Insulator: binding post triple	-hp-	
	1520-0001		2	Insulator: capacitor (used with C1 - C2)	56137	XP
	0340-0007		1	Insulator: ceramic standoff	71590	obd
	0370-0112		1	Knob: black bar concentric	-hp-	
	0370-0113		1	Knob: black bar w/arrow	-hp-	
	0370-0114		1	Knob: red w/arrow	-hp-	
	0360-0016		1	Lug: solder lock #4	78452	718
	0360-0007		4	Lug: solder #10	78189	2501-10-00
	0360-0042		2	Lug: solder 90^{o}	79963	obd
	2260-0001		4	Nut: hex 4-40 x 1/4 in.	-hp-	
	2420-0001		4	Nut: hex 6-32 x 5/16 in. w/lock	83385	obd
	2820-0001		3	Nut: hex 10-32 x 3/8 in.	73743	obd
	2950-0006		3	Nut: hex 1/4-32 x 3/8 in.	73734	9000
	2950-0001		3	Nut: hex 3/8-32 x 1/2 in.	73743	obd
	2950-0037		1	Nut: hex 1/2-16 x 11/16 in.	75915	obd
	2950-0038		1	Nut: hex 1/2-24 x 11/16 in.	75915	903-12
	0590-0039		4	Nut: speed 6-32	78553	C6800-632-1
	0590-0052		2	Nut: speed 6-32	78553	C8020-632-4
	410C-2A		1	Panel: front	-hp-	
	410C-2C		1	Panel: rear	-hp-	
	410C-41A		1	Plate: insulator (used with A1S1 and A2S2)	-hp-	
	1200-0043		1	Plate: insulator (used with Q1)	71785	294457
	1251-0209		1	Plug: telephone (p/o 11036A)	82389	2P-1297
	410B-21C		1	Probe: contact assembly	-hp-	
	410B-21D		1	Probe head	-hp-	
	410B-21F		1	Ring: retainer (p/o 11036A)	-hp-	
	2200-0006		2	Screw: machine 4-40 x 3/8 in. RH	80120	obd
	2200-0014		2	Screw: machine 4-40 x 9/16 in. RH	80120	obd
	2370-0001		20	Screw: machine 6-32 x 1/4 in. RH	80120	obd

Table 6-2. Replaceable Hardware (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
	2390-0007		4	Screw: machine 6-32 x 5/16 in. BH w/lock	83385	obd
	2370-0002		8	Screw: machine 6-32 x 3/8 in. FH	80120	obd
	2370-0003		2	Screw: machine 6-32 x 1/2 in. FH	80120	obd
	410B-21E		1	Sleeve (p/o 11036A)	-hp-	
	1460-0087		1	Spring: diode contact (p/o 11036A)	91260	obd
	1490-0031		1	Stand: tilt	91260	obd
	410C-66A		2	Support: circuit board (used with A3)	-hp-	
	410C-21D		1	Test lead assembly: COM	-hp-	
	410C-21C		1	Test lead assembly: DCA - OHMS	-hp-	
	410C-21A		1	Test lead assembly: DCV (includes R1)	-hp-	
	5020-5388		1	Trim: meter	-hp-	
	11036-62101		1	Tube: socket and cable assembly (p/o 11036A)	-hp-	
	3050-0066		2	Washer: flat #6	73734	obd
	3050-0067		3	Washer: flat 3/8 in. ID	73734	obd
	0900-0016		1	Washer: fuse holder	76680	622710
	2190-0005		2	Washer: lock #4 external	80120	obd
	2190-0004		2	Washer: lock #4 internal	78189	SF1904
	2190-0003		2	Washer: lock #4 split	83385	obd
	2190-0047		30	Washer: lock #6 countersunk	78189	obd
	2190-0011		2	Washer: lock #10 internal	78189	1910
	2190-0028		2	Washer: lock #10 int/ext	78189	4010-18-00
	2190-0027		3	Washer: lock 1/4 in. internal	78189	1914
	2190-0022		4	Washer: lock 3/8 in. ID	78189	1920
	2190-0037		2	Washer: lock 1/2 in. internal	78189	1224-08
	1400-0090		1	Washer: Neoprene	75915	901-2

CODE LIST OF MANUFACTURERS

The following code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) and their latest supplements. The date of revision and the date of the supplements used appear at the bottom of each page. Alphabetical codes have been arbitrarily assigned to suppliers not appearing in the H4 Handbooks.

Code No.	Manufacturer	Address
00000	U.S.A. Common	Any supplier of U.S.
00136	McCoy Electronics	Mount Holly Springs, Pa.
00213	Sage Electronics Corp.	Rochester, N.Y.
00287	Cemco Inc.	Danielson, Conn.
00334	Humidial	Colton, Calif.
00348	Microtron Co., Inc.	Valley Stream, N.Y.
00373	Garlock Inc.	Cherry Hill, N.J.
00656	Aerovox Corp.	New Bedford, Mass.
00779	Amp. Inc.	Harrisburg, Pa.
00781	Aircraft Radio Corp.	Boonton, N.J.
00815	Northern Engineering Laboratories, Inc.	Burlington, Wis.
00853	Sangamo Electric Co., Pickens Div.	Pickens, S.C.
00866	Goe Engineering Co.	City of Industry, Cal.
00891	Carl E. Holmes Corp.	Los Angeles, Calif.
00929	Microlab Inc.	Livingston, N.J.
01002	General Electric Co., Capacitor Dept.	Hudson Falls, N.Y.
01009	Alden Products Co.	Brockton, Mass.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	TRW Semiconductors, Inc.	Lawndale, Calif.
01295	Texas Instruments, Inc., Transistor Products Div.	Dallas, Texas
01349	The Alliance Mfg. Co.	Alliance, Ohio
01589	Pacific Relays, Inc.	Van Nuys, Calif.
01670	Gudebrod Bros. Silk Co.	New York, N.Y.
01930	Amerock Corp.	Rockford, Ill.
01961	Pulse Engineering Co.	Santa Clara, Calif.
02114	Ferroxcube Corp. of America	Saugerties, N.Y.
02116	Wheelock Signals, Inc.	Long Branch, N.J.
02286	Cole Rubber and Plastics Inc.	Sunnyvale, Calif.
02660	Amphenol-Borg Electronics Corp.	Broadview, Ill.
02735	Radio Corp. of America, Semiconductor and Materials Div.	Somerville, N.J.
02771	Vocaline Co. of America, Inc.	Old Saybrook, Conn.
02777	Hopkins Engineering Co.	San Fernando, Calif.
02875	Hudson Tool & Die Co.	Newark, N.J.
03508	G.E. Semiconductor Prod. Dept.	Syracuse, N.Y.
03705	Apex Machine & Tool Co.	Dayton, Ohio
03797	Eldema Corp.	Compton, Calif.
03818	Parker Seal Co.	Los Angeles, Calif.
03877	Transitron Electric Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co., Inc.	Cedar Knolls, N.J.
03954	Singer Co., Diehl Div. Finderne Plant	Sumerville, N.J.
04009	Arrow, Hart and Hegeman Elect. Co.	Hartford, Conn.
04013	Taurus Corp.	Lambertville, N.J.
04062	Arco Electronic Inc.	Great Neck, N.Y.
04222	Hi-Q Division of Aerovox	Myrtle Beach, S.C.
04354	Precision Paper Tube Co.	Wheeling, Ill.
04404	Dymec Division of Hewlett-Packard Co.	Palo Alto, Calif.
04651	Sylvania Electric Products, Microwave Device Div.	Mountain View, Calif.
04673	Dakota Engr. Inc.	Culver City, Calif.
04713	Motorola, Inc., Semiconductor Prod. Div.	Phoenix, Arizona
04732	Filtron Co., Inc. Western Div.	Culver City, Calif.
04773	Automatic Electric Co.	Northlake, Ill.
04796	Sequoia Wire Co.	Redwood City, Calif.
04811	Precision Coil Spring Co.	El Monte, Calif.
04870	P.M. Motor Company	Westchester, Ill.
04919	Component Mfg. Service Co.	W. Bridgewater, Mass.
05006	Twentieth Century Plastics, Inc.	Los Angeles, Calif.
05245	Components Corp.	Chicago, Ill.
05277	Westinghouse Electric Corp. Semi-Conductor Dept.	Youngwood, Pa.
05347	Ultronix, Inc.	San Mateo, Calif.
05397	Union Carbide Corp., Elect. Div.	New York, N.Y.
05574	Viking Ind. Inc.	Canoga Park, Calif.
05593	Icore Electro-Plastics Inc.	Sunnyvale, Calif.
05616	Cosmo Plastic (c/o Electrical Spec. Co.)	Cleveland, Ohio
05624	Barber Colman Co.	Rockford, Ill.
05728	Tiffen Optical Co.	Roslyn Heights, Long Island, N.Y.
05729	Metro-Tel Corp.	Westbury, N.Y.
05783	Stewart Engineering Co.	Santa Cruz, Calif.
05820	Wakefield Engineering Inc.	Wakefield, Mass.
06004	Bassick Co., Div. of Stewart Warner Corp.	Bridgeport, Conn.
06090	Raychem Corp.	Redwood City, Calif.
06175	Bausch and Lomb Optical Co.	Rochester, N.Y.
06402	E.T.A. Products Co. of America	Chicago, Ill.
06540	Amatom Electronic Hardware Co., Inc.	New Rochelle, N.Y.
06555	Beede Electrical Instrument Co., Inc.	Penacook, N.H.
06666	General Devices Co., Inc.	Indianapolis, Ind.
06751	Components Inc., Ariz. Div.	Phoenix, Ariz.
06812	Torrington Mfg. Co., West Div.	Van Nuys, Calif.
06980	Varian Assoc. Eimac Div.	San Carlos, Calif.
07088	Kelvin Electric Co.	Van Nuys, Calif.
07126	Digitran Co.	Pasadena, Calif.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07138	Westinghouse Electric Corp. Electronic Tube Div.	Elmira, N.Y.
07149	Filmohm Corp.	New York, N.Y.
07233	Cinch-Graphik Co.	City of Industry, Calif.
07256	Silicon Transistor Corp.	Carle Place, N.Y.
07261	Avnet Corp.	Culver City, Calif.
07263	Fairchild Camera & Inst. Corp. Semiconductor Div.	Mountain View, Calif.
07322	Minnesota Rubber Co.	Minneapolis, Minn.
07387	Birtcher Corp., The	Monterey Park, Calif.
07397	Sylvania Elect. Prod. Inc., Mt. View Operations	Mountain View, Calif.
07700	Technical Wire Products Inc.	Cranford, N.J.
07829	Bodine Elect. Co.	Chicago, Ill.
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Raytheon Mfg. Co., Semiconductor Div.	Mountain View, Calif.
07980	Hewlett-Packard Co., Boonton Radio Div.	Rockaway, N.J.
08145	U.S. Engineering Co.	Los Angeles, Calif.
08289	Blinn, Delbert Co.	Pomona, Calif.
08358	Burgess Battery Co.	Niagara Falls, Ontario, Canada
08524	Deutsch Fastener Corp.	Los Angeles, Calif.
08664	Bristol Co., The	Waterbury, Conn.
08717	Sloan Company	Sun Valley, Calif.
08718	ITT Cannon Electric Inc., Phoenix Div.	Phoenix, Arizona
08727	National Radio Lab. Inc.	Paramus, N.J.
08792	CBS Electronics Semiconductor Operations, Div of C.B.S. Inc.	Lowell, Mass.
08806	General Electric Co. Miniat. Lamp Dept.	Cleveland, Ohio
08984	Mel-Rain	Indianapolis, Ind.
09026	Babcock Relays Div.	Costa Mesa, Calif.
09134	Texas Capacitor Co.	Houston, Texas
09145	Tech. Ind. Inc. Atohm Elect.	Burbank, Calif.
09250	Electro Assemblies, Inc.	Chicago, Ill.
09353	C & K Components Inc.	Newton, Mass.
09569	Mallory Battery Co. of Canada, Ltd.	Toronto, Ontario, Canada
09922	Burndy Corp.	Norwalk, Conn.
10214	General Transistor Western Corp.	Los Angeles, Calif.
10411	Ti-Tal, Inc.	Berkeley, Calif.
10646	Carborundum Co.	Niagara Falls, N.Y.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Telephone of California, Inc.	So. Pasadena, Calif.
11242	Bay State Electronics Corp.	Waltham, Mass.
11312	Teledyne Inc., Microwave Div.	Palo Alto, Calif.
11314	National Seal	Downey, Calif.
11453	Precision Connector Corp.	Jamaica, N.Y.
11534	Duncan Electronics Inc.	Costa Mesa, Calif.
11711	General Instrument Corp., Semiconductor Div., Products Group	Newark, N.J.
11717	Imperial Electronic, Inc.	Buena Park, Calif.
11870	Melabs, Inc.	Palo Alto, Calif.
12040	National Semiconductor	Danbury, Conn.
12136	Philadelphia Handle Co.	Camden, N.J.
12361	Grove Mfg. Co., Inc.	Shady Grove, Pa.
12574	Gulton Ind. Inc. Data System Div.	Albuquerque, N.M.
12697	Clarostat Mfg. Co.	Dover, N.H.
12728	Elmar Filter Corp.	W. Haven, Conn.
12859	Nippon Electric Co., Ltd.	Tokyo, Japan
12881	Metex Electronics Corp.	Clark, N.J.
12930	Delta Semiconductor Inc.	Newport Beach, Calif.
12954	Dickson Electronics Corp.	Scottsdale, Arizona
13103	Thermolloy	Dallas, Texas
13396	Telefunken (GmbH)	Hanover, Germany
13835	Midland-Wright Div. of Pacific Industries, Inc.	Kansas City, Kansas
14099	Sem-Tech	Newbury Park, Calif.
14193	Calif. Resistor Corp.	Santa Monica, Calif.
14298	American Components, Inc.	Conshohocken, Pa.
14433	ITT Semiconductor, A Div. of Int. Telephone & Telegraph Corp.	West Palm Beach, Fla.
14493	Hewlett-Packard Company	Loveland, Colo.
14655	Cornell Dublier Electric Corp.	Newark, N.J.
14674	Corning Glass Works	Corning, N.Y.
14752	Electro Cube Inc.	San Gabriel, Calif.
14960	Williams Mfg. Co.	San Jose, Calif.
15203	Webster Electronics Co.	New York, N.Y.
15287	Scionics Corp.	Northridge, Calif.
15291	Adjustable Bushing Co.	N. Hollywood, Calif.
15558	Micron Electronics	Garden City, Long Island, N.Y.
15566	Amprobe Inst. Corp.	Lynbrook, N.Y.
15631	Cabletronics	Costa Mesa, Calif.
15772	Twentieth Century Coil Spring Co.	Santa Clara, Calif.
15801	Fenwal Elect. Inc.	Framingham, Mass.
15818	Amelco Inc.	Mt. View, Calif.
16037	Spruce Pine Mica Co.	Spruce Pine, N.C.
16179	Omni-Spectra Inc.	Farmington, Mich.
16352	Computer Diode Corp.	Lodi, N.J.
16585	Boots Aircraft Nut Corp.	Pasadena, Calif.
16688	Ideal Prec. Meter Co., Inc. De Jur Meter Div.	Brooklyn, N.Y.
16758	Delco Radio Div. of G.M. Corp.	Kokoma, Ind.
17109	Thermonetics Inc.	Canoga Park, Calif.
17474	Tranex Company	Mountain View, Calif.
17554	Components Inc.	Biddeford, Me.
17675	Hamlin Metal Products Corp.	Akron, Ohio
17745	Angstrohm Prec. Inc.	No. Hollywood, Calif.
17870	McGraw-Edison Co.	Manchester, N.H.
18042	Power Design Pacific Inc.	Palo Alto, Calif.
18083	Clevite Corp., Semiconductor Div.	Palo Alto, Calif.
18324	Signetics Corp.	Sunnyvale, Calif.
18476	Ty-Car Mfg. Co., Inc.	Holliston, Mass.
18486	TRW Elect. Comp. Div.	Des Plaines, Ill.
18583	Curtis Instrument, Inc.	Mt. Kisco, N.Y.
18612	Vishay Instruments Inc.	Malvern, Pa.
18873	E.I. DuPont and Co., Inc.	Wilmington, Del.
18911	Durant Mfg. Co.	Milwaukee, Wis.
19315	The Bendix Corp., Navigation & Control Div.	Teterboro, N.J.
19500	Thomas A. Edison Industries, Div. of McGraw-Edison Co.	West Orange, N.J.
19589	Concoa	Baldwin Park, Calif.
19644	LRC Electronics	Horseheads, N.Y.
19701	Electra Mfg. Co.	Independence, Kansas
20183	General Atronics Corp.	Philadelphia, Pa.
21226	Executone, Inc.	Long Island City, N.Y.
21335	Fafnir Bearing Co., The	New Britain, Conn.
21520	Fansteel Metallurgical Corp.	N. Chicago, Ill.
23042	Texscan Corp.	Indianapolis, Ind.
23783	British Radio Electronics Ltd.	Washington, D.C.
24455	G.E. Lamp Division	Nela Park, Cleveland, Ohio

CODE LIST OF MANUFACTURERS (Continued)

Code No.	Manufacturer	Address
24655	General Radio Co.	West Concord, Mass.
24681	Memcor Inc., Comp. Div.	Huntington, Ind.
24796	Parelco Inc.	San Juan Capistrano, Calif.
26365	Gries Reproducer Corp.	New Rochelle, N.Y.
26462	Grobet File Co. of America, Inc.	Carlstadt, N.J.
26851	Compac/Hollister Co.	Hollister, Calif.
26992	Hamilton Watch Co.	Lancaster, Pa.
27251	Specialities Mfg. Co., Inc.	Stratford, Conn.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
28520	Heyman Mfg. Co.	Kenilworth, N.J.
30817	Instrument Specialties Co., Inc.	Little Falls, N.J.
33173	G.E. Receiving Tube Dept.	Owensboro, Ky.
35434	Lectrohm Inc.	Chicago, Ill.
36196	Stanwyck Coil Products Ltd.	Hawkesbury, Ontario, Canada
36287	Cunningham, W.H. & Hill, Ltd.	Toronto Ontario, Canada
37942	P.R. Mallory & Co. Inc.	Indianapolis, Ind.
39543	Mechanical Industries Prod. Co.	Akron, Ohio
40920	Miniature Precision Bearings, Inc.	Keene, N.H.
42190	Muter Co.	Chicago, Ill.
43990	C.A. Norgren Co.	Englewood, Colo.
44655	Ohmite Mfg. Co.	Skokie, Ill.
46384	Penn Eng. & Mfg. Corp.	Doylestown, Pa.
47904	Polaroid Corp.	Cambridge, Mass.
48620	Precision Thermometer & Inst. Co.	Southampton, Pa.
49956	Microwave & Power Tube Div.	Waltham, Mass.
52090	Rowan Controller Co.	Westminster, Md.
52983	Sanborn Company	Waltham, Mass.
54294	Shallcross Mfg. Co.	Selma, N.C.
55026	Simpson Electric Co.	Chicago, Ill.
55933	Sonotone Corp.	Elmsford, N.Y.
55938	Raytheon Co. Commercial Apparatus & Systems Div.	So. Norwalk, Conn.
56137	Spaulding Fibre Co., Inc.	Tonawanda, N.Y.
56289	Sprague Electric Co.	North Adams, Mass.
59446	Telex Corp.	Tulsa, Okla.
59730	Thomas & Betts Co.	Elizabeth, N.J.
60741	Triplett Electrical Inst. Co.	Bluffton, Ohio
61775	Union Switch and Signal, Div. of Westinghouse Air Brake Co.	Pittsburgh, Pa.
62119	Universal Electric Co.	Owosso, Mich.
63743	Ward-Leonard Electric Co.	Mt. Vernon, N.Y.
64959	Western Electric Co., Inc.	New York, N.Y.
65092	Weston Inst. Inc. Weston-Newark	Newark, N.J.
66295	Wittek Mfg. Co.	Chicago, Ill.
66346	Minnesota Mining & Mfg. Co. Revere Mincom Div.	St. Paul, Minn.
70276	Allen Mfg. Co.	Hartford, Conn.
70309	Allied Control	New York, N.Y.
70318	Allmetal Screw Product Co., Inc.	Garden City, N.Y.
70417	Amplex, Div. of Chrysler Corp.	Detroit, Mich.
70485	Atlantic India Rubber Works, Inc.	Chicago, Ill.
70563	Amperite Co., Inc.	Union City, N.J.
70674	ADC Products Inc.	Minneapolis, Minn.
70903	Belden Mfg. Co.	Chicago, Ill.
70998	Bird Electronic Corp.	Cleveland, Ohio
71002	Birnbach Radio Co.	New York, N.Y.
71034	Bliley Electric Co., Inc.	Erie, Pa.
71041	Boston Gear Works Div. of Murray Co. of Texas	Quincy, Mass.
71218	Bud Radio, Inc.	Willoughby, Ohio
71279	Cambridge Thermionics Corp.	Cambridge, Mass.
71286	Camloc Fastener Corp.	Paramus, N.J.
71313	Cardwell Condenser Corp.	Lindenhurst L.I., N.Y.
71400	Bussmann Mfg. Div. of McGraw-Edison Co.	St. Louis, Mo.
71436	Chicago Condenser Corp.	Chicago, Ill.
71447	Calif. Spring Co., Inc.	Pico-Rivera, Calif.
71450	CTS Corp.	Elkhart, Ind.
71468	ITT Cannon Electric Inc.	Los Angeles, Calif.
71471	Cinema, Div. Aerovox Corp.	Burbank, Calif.
71482	C.P. Clare & Co.	Chicago, Ill.
71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wis.
71616	Commercial Plastics Co.	Chicago, Ill.
71700	Cornish Wire Co., The	New York, N.Y.
71707	Coto Coil Co., Inc.	Providence, R.I.

Code No.	Manufacturer	Address
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71785	Cinch Mfg. Co., Howard B. Jones Div.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72136	Electro Motive Mfg. Co., Inc.	Willimantic, Conn.
72619	Dialight Corp.	Brooklyn, N.Y.
72656	Indiana General Corp., Electronics Div.	Keasby, N.J.
72699	General Instrument Corp., Cap. Div.	Newark, N.J.
72765	Drake Mfg. Co.	Harwood Heights, Ill.
72825	Hugh H. Eby Inc.	Philadelphia, Pa.
72928	Gudeman Co.	Chicago, Ill.
72962	Elastic Stop Nut Corp.	Union, N.J.
72964	Robert M. Hadley Co.	Los Angeles, Calif.
72982	Erie Technological Products, Inc.	Erie, Pa.
73061	Hansen Mfg. Co., Inc.	Princeton, Ind.
73076	H.M. Harper Co.	Chicago, Ill.
73138	Helipot Div. of Beckman Inst., Inc.	Fullerton, Calif.
73293	Hughes Products Division of Hughes Aircraft Co.	Newport Beach, Calif.
73445	Amperex Elect Co.	Hicksville, L.I., N.Y.
73506	Bradley Semiconductor Corp.	New Haven, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73586	Circle F Mfg. Co.	Trenton, N.J.
73682	George K. Garrett Co., Div. MSL Industries Inc.	Philadelphia, Pa.
73734	Federal Screw Products Inc.	Chicago, Ill.
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	General Industries Co., The	Elyria, Ohio
73846	Goshen Stamping & Tool Co.	Goshen, Ind.
73899	JFD Electronics Corp.	Brooklyn, N.Y.
73905	Jennings Radio Mfg. Corp.	San Jose, Calif.
73957	Groov-Pin Corp.	Ridgefield, N.J.
74276	Signalite Inc.	Neptune, N.J.
74455	J.H. Winns, and Sons	Winchester, Mass.
74861	Industrial Condenser Corp.	Chicago, Ill.
74868	R.F. Products Division of Amphenol-Borg Electronics Corp.	Danbury, Conn.
74970	E.F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
75263	Keystone Carbon Co., Inc.	St. Marys, Pa.
75378	CTS Knights Inc.	Sandwich, Ill.
75382	Kulka Electric Corporation	Mt. Vernon, N.Y.
75818	Lenz Electric Mfg. Co.	Chicago, Ill.
75915	Littlefuse, Inc.	Des Plaines, Ill.
76005	Lord Mfg. Co.	Erie, Pa.
76210	C.W. Marwedel	San Francisco, Calif.
76433	General Instrument Corp., Micamold Division	Newark, N.J.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76493	J.W. Miller Co.	Los Angeles, Calif.
76530	Cinch-Monadnock, Div. of United Carr Fastener Corp.	San Leandro, Calif.
76545	Mueller Electric Co.	Cleveland, Ohio
76703	National Union	Newark, N.J.
76854	Oak Manufacturing Co.	Crystal Lake, Ill.
77068	The Bendix Corp., Electrodynamics Div.	N. Hollywood, Calif.
77075	Pacific Metals Co.	San Francisco, Calif.
77221	Phanostran Instrument and Electronic Co.	South Pasadena, Calif.
77252	Philadelphia Steel and Wire Corp.	Philadelphia, Pa.
77342	American Machine & Foundry Co. Potter & Brumfield Div.	Princeton, Ind.
77630	TRW Electronic Components Div.	Camden, N.J.
77638	General Instrument Corp., Rectifier Div.	Brooklyn, N.Y.
77764	Resistance Products Co.	Harrisburg, Pa.
77969	Rubbercraft Corp. of Calif.	Torrance, Calif.
78189	Shakeproof Division of Illinois Tool Works	Elgin, Ill.
78277	Sigma	So. Braintree, Mass.
78283	Signal Indicator Corp.	New York, N.Y.
78290	Struthers-Dunn Inc.	Pitman, N.J.
78424	Speciality Leather Prod. Co.	Newark, N.J.
78452	Thompson-Bremer & Co.	Chicago, Ill.
78471	Tilley Mfg. Co.	San Francisco, Calif.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78493	Standard Thomson Corp.	Waltham, Mass.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78790	Transformer Engineers	San Gabriel, Calif.

Code No.	Manufacturer	Address
78947	Ucinite Co.	Newtonville, Mass.
79136	Waldes Kohinoor Inc.	Long Island City, N.Y.
79142	Veeder Root, Inc.	Hartford, Conn.
79251	Wenco Mfg. Co.	Chicago, Ill.
79727	Continental-Wirt Electronics Corp.	Philadelphia, Pa.
79963	Zierick Mfg. Corp.	New Rochelle, N.Y.
80031	Mepco Division of Sessions Clock Co.	Morristown, N.J.
80120	Schnitzer Alloy Products Co.	Elizabeth, N.J.
80131	Electronic Industries Association. Any brand Tube meeting EIA Standards-Washington, DC.	
80207	Unimax Switch, Div. Maxon Electronics Corp.	Wallingford, Conn.
80223	United Transformer Corp.	New York, N.Y.
80248	Oxford Electric Corp.	Chicago, Ill.
80294	Bourns Inc.	Riverside, Calif.
80411	Acro Div. of Robertshaw Controls Co.	Columbus, Ohio
80486	All Star Products Inc.	Defiance, Ohio
80509	Avery Label Co.	Monrovia, Calif.
80583	Hammarlund Co., Inc.	Mars Hill, N.C.
80640	Stevens, Arnold, Co., Inc.	Boston, Mass.
80813	Dimco Gray Co.	Dayton, Ohio
81030	International Instruments Inc.	Orange, Conn.
81073	Grayhill Co.	LaGrange, Ill.
81095	Triad Transformer Corp.	Venice, Calif.
81312	Winchester Elec. Div. Litton Ind., Inc.	Oakville, Conn.
81349	Military Specification	. . . . . .
81483	International Rectifier Corp.	El Segundo, Calif.
81541	Airpax Electronics, Inc.	Cambridge, Maryland
81860	Barry Controls, Div. Barry Wright Corp.	Watertown, Mass.
82042	Carter Precision Electric Co.	Skokie, Ill.
82047	Sperti Faraday Inc., Copper Hewitt Electric Div.	Hoboken, N.J.
82116	Electric Regulator Corp.	Norwalk, Conn.
82142	Jeffers Electronics Division of Speer Carbon Co.	Du Bois, Pa.
82170	Fairchild Camera & Inst. Corp. Space & Defense System Div.	Paramus, N.J.
82209	Maguire Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod. Inc. Electronic Tube Division	Emporium, Pa.
82376	Astron Corp.	East Newark, Harrison, N.J.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Metals & Controls Inc. Spencer Products	Attleboro, Mass.
82768	Phillips-Advance Control Co.	Joliet, Ill.
82866	Research Products Corp.	Madison, Wis.
82877	Rotron Mfg. Co., Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.
83014	Hartwell Corp.	Los Angeles, Calif.
83058	Carr Fastener Co.	Cambridge, Mass.
83086	New Hampshire Ball Bearing, Inc.	Peterborough, N.H.
83125	General Instrument Corp., Capacitor Div.	Darlington, S.C.
83148	ITT Wire and Cable Div.	Los Angeles, Calif.
83186	Victory Eng. Corp.	Springfield, N.J.
83298	Bendix Corp., Red Bank Div.	Red Bank, N.J.
83315	Hubbell Corp.	Mundelein, Ill.
83324	Rosan Inc.	Newport Beach, Calif.
83330	Smith, Herman H., Inc.	Brooklyn, N.Y.
83332	Tech Labs	Palisade's Park, N.J.
83385	Central Screw Co.	Chicago, Ill.
83501	Gavitt Wire and Cable Co. Div. of Amerace Corp.	Brookfield, Mass.
83594	Burroughs Corp. Electronic Tube Div.	Plainfield, N.J.
83740	Union Carbide Corp. Consumer Prod. Div.	New York, N.Y.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.
83821	Loyd Scruggs Co.	Festus, Mo.
83942	Aeronautical Inst. & Radio Co.	Lodi, N.J.
84171	Arco Electronics Inc.	Great Neck, N.Y.
84396	A.J. Glesener Co., Inc.	San Francisco, Calif.
84411	TRW Capacitor Div.	Ogallala, Neb.
84970	Sarkes Tarzian, Inc.	Bloomington, Ind.
85454	Boonton Molding Company	Boonton, N.J.
85471	A.B. Boyd Co.	San Francisco, Calif.
85474	R.M. Bracamonte & Co.	San Francisco, Calif.

CODE LIST OF MANUFACTURERS (Continued)

Code No.	Manufacturer	Address
85660	Koiled Kords, Inc.	Hamden, Conn.
85911	Seamless Rubber Co.	Chicago, Ill.
86174	Fafnir Bearing Co.	Los Angeles, Calif.
86197	Clifton Precision Products Co., Inc.	Clifton Heights, Pa.
86579	Precision Rubber Products Corp.	Dayton, Ohio
86684	Radio Corp. of America, Electronic Comp. & Devices Div.	Harrison, N.J.
86928	Seastrom Mfg. Co.	Glendale, Calif.
87034	Marco Industries	Anaheim, Calif.
87216	Philco Corporation (Lansdale Division)	Lansdale, Pa.
87473	Western Fibrous Glass Products Co.	San Francisco, Calif.
87664	Van Waters & Rogers Inc.	San Francisco, Calif.
87930	Tower Mfg. Corp.	Providence, R.I.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
88220	Gould-National Batteries, Inc.	St. Paul, Minn.
88698	General Mills, Inc.	Buffalo, N.Y.
89231	Graybar Electric Co.	Oakland, Calif.
89473	G.E. Distributing Corp.	Schenectady, N.Y.
89665	United Transformer Co.	Chicago, Ill.
90030	United Shoe Machinery Corp.	Beverly, Mass.
90179	US Rubber Co., Consumer Ind. & Plastics Prod. Div.	Passaic, N.J.
90970	Bearing Engineering Co.	San Francisco, Calif.
91146	ITT Cannon Elect, Inc., Salem Div.	Salem, Mass.
91260	Connor Spring Mfg. Co.	San Francisco, Calif.
91345	Miller Dial & Nameplate Co.	El Monte, Calif.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat Inc.	Attleboro, Mass.
91637	Dale Electronics, Inc.	Columbus, Nebr.
91662	Elco Corp.	Willow Grove, Pa.
91737	Gremar Mfg. Co., Inc.	Wakefield, Mass.
91827	K F Development Co.	Redwood City, Calif.
91886	Malco Mfg. Co., inc.	Chicago, Ill.
91929	Honeywell Inc., Micro Switch Div.	Freeport, Ill.
91961	Nahm-Bros. Spring Co.	Oakland, Calif.
92180	Tru-Connector Corp.	Peabody, Mass.
92367	Elgeet Optical Co. Inc.	Rochester, N.Y.
92607	Tensolite Insulated Wire Co., Inc.	Tarrytown, N.Y.
92702	IMC Magnetics Corp.	Wesbury Long Island, N.Y.
92966	Hudson Lamp Co.	Kearney, N.J.
93332	Sylvania Electric Prod. Inc. Semiconductor Div.	Woburn, Mass.
93369	Robbins & Myers Inc.	Palisades Park, N.J.
93410	Stemco Controls, Div. of Essex Wire Corp.	Mansfield, Ohio
93632	Waters Mfg. Co.	Culver City, Calif.
93929	G.V. Controls	Livingston, N.J.
94137	General Cable Corp.	Bayonne, N.J.
94142	Phelps Dodge	Yonkers, N.Y.
94144	Raytheon Co., Comp. Div., Ind. Comp. Operations	Quincy, Mass.
94148	Scientific Electronics Products, Inc.	Loveland, Colo.
94154	Wagner Elect. Corp., Tung-Sol Div.	Newark, N.J.
94197	Curtiss-Wright Corp. Electronics Div.	East Paterson, N.J.
94222	South Chester Corp.	Chester, Pa.
94330	Wire Cloth Products, Inc.	Bellwood, Ill.
94375	Automatic Metal Products Co.	Brooklyn, N.Y.
94682	Worcester Pressed Aluminum Corp.	Worcester, Mass.
94696	Magnecraft Electric Co.	Chicago, Ill.
95023	George A. Philbrick Researchers, Inc.	Boston, Mass.
95236	Allies Products Corp.,	Dania, Fla.
95238	Continental Connector Corp.	Woodside, N.Y.
95263	Leecraft Mfg. Co., Inc.	Long Island, N.Y.
95265	National Coil Co.	Sheridan, Wyo.
95275	Vitramon, Inc.	Bridgeport, Conn.
95348	Gordos Corp.	Bloomfield, N.J.
95354	Methode Mfg. Co.	Rolling Meadows, Ill.
95566	Arnold Engineering Co.	Marengo, Ill.
95712	Dage Electric Co., Inc.	Franklin, Ind.
95984	Siemon Mfg. Co.	Wayne, Ill.
95987	Weckesser Co.	Chicago, Ill.
96067	Microwave Assoc., West Inc.	Sunnyvale, Calif.
96095	Hi-Q Div. of Aerovox Corp.	Olean, N.Y.
96256	Thordarson-Meissner Inc.	Mt. Carmel, Ill.
96296	Solar Manufacturing Co.	Los Angeles, Calif.
96306	Microswitch, Div. of Minn.-Honeywell	Freeport, Ill.
96330	Carlton Screw Co.	Chicago, Ill.
96341	Microwave Associates, Inc.	Burlington, Mass.
96501	Excel Transformer Co.	Oakland, Calif.
96733	San Fernando Elect. Mfg. Co.	San Fernando, Calif.
96881	Thomson Ind. Inc.	Long Is., N.Y.
97464	Industrial Retaining Ring Co.	Irvington, N.J.
97539	Automatic & Precision Mfg.	Englewood, N.J.
97979	Reon Resistor Corp.	Yonkers, N.Y.
97983	Litton System Inc., Adler-Westrex Commun. Div.	New Rochelle, N.Y.
98141	R-Troncis, Inc.	Jamaica, N.Y.
98159	Rubber Teck, Inc.	Gardena, Calif.
98220	Hewlett-Packard Co., Moseley Div.	Pasadena, Calif.
98278	Microdot, Inc.	So. Pasadena, Calif.
98291	Sealectro Corp.	Mamaroneck, N.Y.
98376	Zero Mfg. Co.	Burbank, Calif.
98410	Etc Inc.	Cleveland, Ohio
98731	General Mills Inc., Electronics Div.	Minneapolis, Minn.
98734	Paeco Div. of Hewlett-Packard Co.	Palo Alto, Calif.
98821	North Hills Electronics, Inc.	Glen Cove, N.Y.
98978	International Electronic Research Corp.	Burbank, Calif.
99109	Columbia Technical Corp.	New York, N.Y.
99313	Varian Associates	Palo Alto, Calif.
99378	Atlee Corp.	Winchester, Mass.
99515	Marshall Ind., Capacitor Div.	Monrovia, Calif.
99707	Control Switch Division, Controls Co. of America	El Segundo, Calif.
99800	Delevan Electronics Corp.	East Aurora, N.Y.
99848	Wilco Corporation	Indianapolis, Ind.
99928	Branson Corp.	Whippany, N.J.
99934	Renbrandt, Inc.	Boston, Mass.
99942	Hoffman Electronics Corp. Semiconductor Div.	El Monte, Calif.
99957	Technology Instrument Corp. of Calif.	Newbury Park, Calif.

THE FOLLOWING HP VENDORS HAVE NO NUMBER ASSIGNED IN THE LATEST SUPPLEMENT TO THE FEDERAL SUPPLY CODE FOR MANUFACTURERS HANDBOOK.

Code No.	Manufacturer	Address
0000F	Malco Tool and Die	Los Angeles, Calif.
0000Z	Willow Leather Products Corp.	Newark, N.J.
000AB	ETA	England
000BB	Precision Instrument Components Co.	Van Nuys, Calif.
000CS	Hewlett-Packard Co., Colorado Springs	Colorado Springs, Colorado
000MM	Rubber Eng. & Development	Hayward, Calif.
000NN	A "N" D Mfg. Co.	San Jose, Calif.
000QQ	Cooltron	Oakland, Calif.
000WW	California Eastern Lab.	Burlington, Calif.
000YY	S.K. Smith Co.	Los Angeles, Calif.

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HEWLETT-PACKARD SERVICE CENTERS AND FIELD OFFICES

UNITED STATES

ALABAMA
P.O. Box 4207
2003 Byrd Spring Road S.W.
Huntsville 35802
Tel: (205) 881-4591
TWX: 810-726-2204

ARIZONA
3009 North Scottsdale Road
Scottsdale 85251
Tel: (602) 945-7601
TWX: 910-950-1282

5737 East Broadway
Tucson 85716
Tel: (602) 298-2313
TWX: 910-952-1162

CALIFORNIA
1430 East Orangethorpe Ave.
Fullerton 92631
Tel: (714) 870-1000

3939 Lankershim Boulevard
North Hollywood 91604
Tel: (213) 877-1282
TWX: 910-499-2170

1101 Embarcadero Road
Palo Alto 94303
Tel: (415) 327-6500
TWX: 910-373-1280

2591 Carlsbad Avenue
Sacramento 95821
Tel: (916) 482-1463
TWX: 910-367-2092

1055 Shafter Street
San Diego 92106
Tel: (714) 223-8103
TWX: 910-335-2000

COLORADO
7965 East Prentice
Englewood 80110
Tel: (303) 771-3455
TWX: 910-935-0705

CONNECTICUT
508 Tolland Street
East Hartford 06108
Tel: (203) 289-9394
TWX: 710-425-3416

111 East Avenue
Norwalk 06851
Tel: (203) 853-1251
TWX: 710-468-3750

DELAWARE
3941 Kennett Pike
Wilmington 19807
Tel: (302) 655-6161
TWX: 510-666-2214

FLORIDA
P.O. Box 545
Suite 106
9999 N.E. 2nd Avenue
Miami Shores 33153
Tel: (305) 754-4565
TWX: 810-848-7262

P.O. Box 20007
Herndon Station 32814
621 Commonwealth Avenue
Orlando
Tel: (305) 841-3970
TWX: 810-850-0113

P.O. Box 8128
Madeira Beach 33708
410 150th Avenue
St. Petersburg
Tel: (813) 391-0211
TWX: 810-863-0366

GEORGIA
P.O. Box 28234
450 Interstate North
Atlanta 30328
Tel: (404) 436-6181
TWX: 810-766-4890

ILLINOIS
5500 Howard Street
Skokie 60076
Tel: (312) 677-0400
TWX: 910-223-3613

INDIANA
3839 Meadows Drive
Indianapolis 46205
Tel: (317) 546-4891
TWX: 810-341-3263

LOUISIANA
P.O. Box 856
1942 Williams Boulevard
Kenner 70062
Tel: (504) 721-6201
TWX: 810-955-5524

MARYLAND
6707 Whitestone Road
Baltimore 21207
Tel: (301) 944-5400
TWX: 710-862-0850

P.O. Box 1648
2 Choke Cherry Road
Rockville 20850
Tel: (301) 948-6370
TWX: 710-828-9684

MASSACHUSETTS
32 Hartwell Ave.
Lexington 02173
Tel: (617) 861-8960
TWX: 710-326-6904

MICHIGAN
24315 Northwestern Highway
Southfield 48075
Tel: (313) 353-9100
TWX: 810-232-1532

MINNESOTA
2459 University Avenue
St. Paul 55114
Tel: (612) 645-9461
TWX: 910-563-3734

MISSOURI
9208 Wyoming Place
Kansas City 64114
Tel: (816) 333-2445
TWX: 910-771-2087

2812 South Brentwood Blvd.
St. Louis 63144
Tel: (314) 962-5000
TWX: 910-760-1670

NEW JERSEY
W. 120 Century Road
Paramus 07652
Tel: (201) 265-5000
TWX: 710-990-4951

1060 N. Kings Highway
Cherry Hill 08034
Tel: (609) 667-4000
TWX: 710-892-4945

NEW MEXICO
P.O. Box 8366
Station C
6501 Lomas Boulevard N.E.
Albuquerque 87108
Tel: (505) 255-5586
TWX: 910-989-1665

156 Wyatt Drive
Las Cruces 88001
Tel: (505) 526-2485
TWX: 910-983-0550

NEW YORK
1702 Central Avenue
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Tel: (518) 869-8462
TWX: 710-441-8270

1219 Campville Road
Endicott 13764
Tel: (607) 754-0050
TWX: 510-252-0890

82 Washington Street
Poughkeepsie 12601
Tel: (914) 454-7330
TWX: 510-248-0012

39 Saginaw Drive
Rochester 14623
Tel: (716) 473-9500
TWX: 510-253-5981

1025 Northern Boulevard
Roslyn, Long Island 11576
Tel: (516) 869-8400
TWX: 510-223-0811

5858 East Molloy Road
Syracuse 13211
Tel: (315) 454-2486
TWX: 710-541-0482

NORTH CAROLINA
P.O. Box 5188
1923 North Main Street
High Point 27262
Tel: (919) 882-6873
TWX: 510-926-1516

OHIO
25575 Center Ridge Road
Cleveland 44145
Tel: (216) 835-0300
TWX: 810-427-9129

3460 South Dixie Drive
Dayton 45439
Tel: (513) 298-0351
TWX: 810-459-1925

OKLAHOMA
2919 United Founders Boulevard
Oklahoma City 73112
Tel: (405) 848-2801
TWX: 910-830-6862

OREGON
Westhills Mall, Suite 158
4475 S.W. Scholls Ferry Road
Portland 97225
Tel: (503) 292-9171
TWX: 910-464-6103

PENNSYLVANIA
2500 Moss Side Boulevard
Monroeville 15146
Tel: (412) 271-0724
TWX: 710-797-3650

1021 8th Avenue
King of Prussia Industrial Park
King of Prussia 19406
Tel: (215) 265-7000
TWX: 510-660-2670

RHODE ISLAND
873 Waterman Ave.
East Providence 02914
Tel: (401) 434-5535
TWX: 710-381-7573

TEXAS
P.O. Box 1270
201 E. Arapahoe Rd.
Richardson 75080
Tel: (214) 231-6101
TWX: 910-867-4723

P.O. Box 22813
4242 Richmond Avenue
Houston 77027
Tel: (713) 667-2407
TWX: 910-881-2645

GOVERNMENT CONTRACT OFFICE
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Tel: (512) 434-4171
TWX: 910-871-1170

UTAH
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Tel: (801) 486-8166
TWX: 910-925-5681

VIRGINIA
P.O. Box 6514
2111 Spencer Road
Richmond 23230
Tel: (703) 282-5451
TWX: 710-956-0157

WASHINGTON
433-108th N.E.
Bellevue 98004
Tel: (206) 454-3971
TWX: 910-443-2303

FOR U.S. AREAS NOT LISTED:
Contact the regional office nearest you: Atlanta, Georgia . . . North Hollywood, California . . . Paramus, New Jersey . . . Skokie, Illinois. Their complete addresses are listed above.

CANADA

ALBERTA
Hewlett-Packard (Canada) Ltd.
11745 Jasper Ave.
Edmonton
Tel: (403) 482-5561
TWX: 610-831-2431

BRITISH COLUMBIA
Hewlett-Packard (Canada) Ltd.
3284 East 1st Ave.
Vancouver 12
Tel: (604) 255-7781
TWX: 610-922-5059

MANITOBA
Hewlett-Packard (Canada) Ltd.
511 Bradford Ct.
St. James
Tel: (204) 786-7581
TWX: 610-671-3531

NOVA SCOTIA
Hewlett-Packard (Canada) Ltd.
2745 Dutch Village Rd.
Suite 203
Halifax
Tel: (902) 455-0511
TWX: 610-271-4482

ONTARIO
Hewlett-Packard (Canada) Ltd.
880 Lady Ellen Place
Ottawa 3
Tel: (613) 722-4223
TWX: 610-562-1952

Hewlett-Packard (Canada) Ltd.
50 Galaxy Blvd.
Rexdale
Tel: (416) 677-9611
TWX: 610-492-4246

QUEBEC
Hewlett-Packard (Canada) Ltd.
275 Hymus Boulevard
Pointe Claire
Tel: (514) 697-4232
TWX: 610-422-3022
Telex: 01-20607

FOR CANADIAN AREAS NOT LISTED:
Contact Hewlett-Packard (Canada) Ltd. in Pointe Claire, at the complete address listed above.

CENTRAL AND SOUTH AMERICA

ARGENTINA
Hewlett-Packard Argentina S.A.C.e.I
Lavalle 1171 - 3°
Buenos Aires
Tel: 35-0436, 35-0627, 35-0431
Telex: 012-1009
Cable: HEWPACKARG

BRAZIL
Hewlett-Packard Do Brasil I.e.C Ltda.
Rua Coronel: Oscar Porto, 691
Sao Paulo - 8, SP
Tel: 71-1503
Cable: HEWPACK Sao Paulo

Hewlett-Packard Do Brasil I.e.C. Ltda.
Avenida Franklin Roosevelt 84-grupo 203
Rio de Janeiro, ZC-39, GB
Tel: 32-9733
Cable: HEWPACK Rio de Janeiro

CHILE
Hector Calcagni P.
Bustos, 1932-3er Piso
Casilla 13942
Santiago
Tel: 4-2396

COLOMBIA
Instrumentacion
Henrik A. Langebaek & Kier Ltda.
Carrera 7 #48-59
Apartado Aereo 6287
Bogota, 1 D.E.
Tel: 45-78-06, 45-55-46
Cable: AARIS Bogota

COSTA RICA
Lic. Alfredo Gallegos Gurdián
Apartado 3243
San José
Tel: 21-86-13
Cable: GALGUR San José

ECUADOR
Laboratorios de Radio-Ingenieria
Calle Guayaquil 1246
Post Office Box 3199
Quito
Tel: 12496
Cable: HORVATH Quito

EL SALVADOR
Electrónica
Apartado Postal 1589
27 Avenida Norte 1133
San Salvador
Tel: 25-74-50
Cable: ELECTRONICA San Salvador

GUATEMALA
Olander Associates Latin America
Apartado 1226
7a. Calle, 0-22, Zona 1
Guatemala City
Tel: 22812
Cable: OLALA Guatemala City

JAMAICA
General Engineering Services, Ltd.
27 Dunrobin Ave.
Kingston
Tel: 42657
Cable: GENSERV

MEXICO
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Moras 439
Col. del Valle
Mexico 12, D.F.
Tel: 5-75-46-49

NICARAGUA
Roberto Terán G.
Apartado Postal 689
Edificio Terán
Managua
Tel: 3451, 3452
Cable: ROTERAN Managua

PANAMA
Electronica Balboa, S.A.
P.O. Box 4929
Ave. Manuel Espinosa No. 13-50
Bldg. Alina
Panama City
Tel: 30833
Cable: ELECTRON Panama City

PERU
Fernando Ezeta B.
Avenida Petit Thouars 4719
Miraflores
Casilla 3061
Lima
Tel: 50346
Cable: FEPERU Lima

PUERTO RICO
San Juan Electronics, Inc.
P.O. Box 5167
Ponce de Leon 154
Pda. 3-Pta. de Tierra
San Juan 00906
Tel: (809) 725-3342
Cable: SATRONICS San Juan
Telex: SATRON 3450 332

URUGUAY
Pablo Ferrando S.A.
Comercial e Industrial
Avenida Italia 2877
Casilla de Correo 370
Montevideo
Tel: 40-3102
Cable: RADIUM Montevideo

VENEZUELA
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Apartado del Este 10934
Chacaito
Caracas
Tel: 71.88.05, 71.88.69, 71.88.76
Cable: HEWPACK Caracas

FOR AREAS NOT LISTED, CONTACT:
Hewlett-Packard Inter-Americas
3200 Hillview Ave.
Palo Alto, California 94304
Tel: (415) 326-7000
TWX: 910-373-1267
Cable: HEWPACK Palo Alto
Telex: 034-8461

EUROPE

AUSTRIA
Unilabor GmbH
Wissenschaftliche Instrumente
Rummelhardtgasse 6/3
P.O. Box 33
Vienna A-1095
Tel: 42 61 81
Cable: LABORINSTRUMENT Vienna
Telex: 75 762

BELGIUM
Hewlett-Packard Benelux S.A.
348 Boulevard du Souverain
Brussels 16
Tel: 72 22 40
Cable: PALOBEN Brussels
Telex: 23 494

DENMARK
Hewlett-Packard A/S
Langebjerg 6
2850 **Naerum**
Tel: (01) 80 40 40
Cable: HEWPACK AS
Telex: 66 40

FINLAND
Hewlett-Packard Oy
Gyldenintie 3
Helsinki 20
Tel: 67 35 38
Cable: HEWPACKOY-Helsinki
Telex: 12-1563

FRANCE
Hewlett-Packard France
Quartier de Courtaboeuf
Boite Postale No. 6
91 Orsay
Tel: 920 88 01
Cable: HEWPACK Orsay
Telex: 60048

Hewlett-Packard France
4 Quai des Etroits
69 **Lyon** 5ème
Tel: 42 63 45
Cable: HEWPACK Lyon
Telex: 31617

GERMANY
Hewlett-Packard Vertriebs-GmbH
Lietzenburgerstrasse 30
1 **Berlin W** 30
Tel: 24 60 65/66
Telex: 18 34 05

Hewlett-Packard Vertriebs-GmbH
Herrenbergerstrasse 110
703 **Böblingen,** Württemberg
Tel: 07031-6671
Cable: HEPAG Böblingen
Telex: 72 65 739

Hewlett-Packard Vertriebs-GmbH
Achenbachstrasse 15
4 **Düsseldorf** 1
Tel: 68 52 58/59
Telex: 85 86 533

Hewlett-Packard Vertriebs-GmbH
Berliner Strasse 117
6 **Frankfurt Nieder-Eschbach**
Tel: 50 10 64
Cable: HEWPACKSA Frankfurt
Telex: 41 32 49

Hewlett-Packard Vertriebs-GmbH
Beim Strohhause 26
2 **Hamburg** 1
Tel: 24 05 51/52
Cable: HEWPACKSA Hamburg
Telex: 21 53 32

Hewlett-Packard Vertriebs-GmbH
Reginfriedstrasse 13
8 **München** 9
Tel: 0811 69 59 71/75
Cable: HEWPACKSA München
Telex: 52 49 85

GREECE
Kostas Karayannis
18, Ermou Street
Athens 126
Tel: 230 301
Cable: RAKAR Athens
Telex: 21 59 62

IRELAND
Hewlett-Packard Ltd.
224 Bath Road
Slough, Bucks, England
Tel: Slough 753-33341
Cable: HEWPIE Slough
Telex: 84413

ITALY
Hewlett-Packard Italiana S.p.A.
Via Amerigo Vespucci 2
20124 **Milano**
Tel: 6251 (10 lines)
Cable: HEWPACKIT Milan
Telex: 32046

Hewlett-Packard Italiana S.p.A.
Palazzo Italia
Piazza Marconi 25
00144 **Rome** - Eur
Tel: 591 2544
Cable: HEWPACKIT Rome
Telex: 61514

NETHERLANDS
Hewlett-Packard Benelux, N.V.
Weerdestein 117
Amsterdam, Z 11
Tel: 42 77 77
Cable: PALOBEN Amsterdam
Telex: 13 216

NORWAY
Hewlett-Packard Norge A/S
Box 149
Nesveien 13
Haslum
Tel: 53 83 60
Cable: HEWPACK Oslo
Telex: 6621

PORTUGAL
Telectra
Rua Rodrigo da Fonseca 103
P.O. Box 2531
Lisbon 1
Tel: 68 60 72
Cable: TELECTRA Lisbon
Telex: 1598

SPAIN
Ataio Ingenieros
Ganduxer 76
Barcelona 6
Tel: 211-44-66

Ataio Ingenieros
Enrique Larreta 12
Madrid, 16
Tel: 235 43 44
Cable: TELEATAIO Madrid
Telex: 2 72 49

SWEDEN
Hewlett-Packard (Sverige) AB
Hagakersgatan 9C
S 431 04 **Mölndal** 4
Tel: 031 - 27 68 00

Hewlett-Packard (Sverige) AB
Svetsarvägen 7
S171 20 **Solna** 1
Tel: (08) 98 12 50
Cable: MEASUREMENTS Stockholm
Telex: 10721

SWITZERLAND
Hewlett Packard (Schweiz) AG
Zurcherstrasse 20
8952 Schlieren
Zurich
Tel: (051) 98 18 21/24
Cable: HEWPACKAG Zurich
Telex: 53933

Hewlett Packard (Schweiz) A.G.
Rue du Bois-du-Lan 7
1217 Meyrin-**Geneva**
Tel: (022) 41 54 00
Cable: HEWPACKSA Geneva
Telex: 2 24 86

TURKEY
Telekom Engineering Bureau
P.O. Box 376 - Galata
Istanbul
Tel: 49 40 40
Cable: TELEMATION Istanbul

UNITED KINGDOM
Hewlett-Packard Ltd.
224 Bath Road
Slough, Bucks
Tel: Slough 33341
Cable: HEWPIE Slough
Telex: 84413

YUGOSLAVIA
Belram S.A.
83 avenue des Mimosas
Brussels 15, Belgium
Tel: 34 33 32, 34 26 19
Cable: BELRAMEL Brussels
Telex: 21790

FOR AREAS NOT LISTED, CONTACT:
Hewlett-Packard S.A.
Rue du Bois-du-Lan 7
1217 Meyrin-**Geneva**
Tel: (022) 41 54 00
Cable: HEWPACKSA Geneva
Telex: 2.24.86

AFRICA, ASIA, AUSTRALIA

ANGOLA
Telectra Empresa Técnica de Equipamentos Eléctricos SAR
Rua de Barbosa Rodrigues 42-1°
Box 6487
Luanda
Cable: TELECTRA Luanda

AUSTRALIA
Hewlett-Packard Australia Pty. Ltd.
22-26 Weir Street
Glen Iris, 3146
Victoria
Tel: 20.1371 (4 lines)
Cable: HEWPARD Melbourne
Telex: 31024

Hewlett-Packard Australia Pty. Ltd.
61 Alexander Street
Crows Nest 2065
New South Wales
Tel: 43.7866
Cable: HEWPARD Sydney
Telex: 21561

Hewlett-Packard Australia Pty. Ltd.
97 Churchill Road
Prospect 5082
South Australia
Tel: 65.2366
Cable: HEWPARD Adelaide

Hewlett Packard Australia Pty. Ltd.
2nd Floor, Suite 13
Casablanca Buildings
196 Adelaide Terrace
Perth, W.A. 6000
Tel: 21-3330

CEYLON
United Electricals Ltd.
P.O. Box 681
Yahala Building
Staples Street
Colombo 2
Tel: 5496
Cable: HOTPOINT Colombo

CYPRUS
Kypronics
19-19D Hommer Avenue
P.O. Box 752
Nicosia
Tel: 6282-75628
Cable: HE-I-NAMI

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58/59 Cunningham St.
Addis Ababa
Tel: 12285
Cable: ASACO Addisababa

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P.O. Box 297
1511, Prince's Building
10, Chater Road
Hong Kong
Tel: 240168, 232735
Cable: SCHMIDTCO Hong Kong

INDIA
The Scientific Instrument Co., Ld.
6, Tej Bahadur Sapru Road
Allahabad 1
Tel: 2451
Cable: SICO Allahbad

The Scientific Instrument Co., Ltd.
12/5 Dickenson Road
Bangalore -1
Cable: SICO Bangalore

The Scientific Instrument Co., Ld.
240, Dr. Dadabhai Naoroji Road
Bombay 1
Tel: 26-2642
Cable: SICO Bombay

The Scientific Instrument Co., Ld.
11, Esplanade East
Calcutta 1
Tel: 23-4129
Cable: SICO Calcutta

The Scientific Instrument Co., Ld.
30, Mount Road
Madras 2
Tel: 86339
Cable: SICO Madras

The Scientific Instrument Co. Ltd.
5-8-525 Mahatma Gandhi Road
Hyderabad-1 (A-P) India
Cable: SICO Hyderabad

The Scientific Instrument Co., Ld.
B-7, Ajmeri Gate Extn.
New Delhi 1
Tel: 27-1053
Cable: SICO New Delhi

INDONESIA
Bah Bolon Trading Coy. N.V.
Djalah Merdeka 29
Bandung

IRAN
Telecom, Ltd.
P. O. Box 1812
240 Kh. Saba Shomali
Teheran
Tel: 43850, 48111
Cable: BASCOM Teheran

ISRAEL
Electronics & Engineering Div. of Motorola Israel Ltd.
16, Kremenetski Street
Tel-Aviv
Tel: 35021 (4 lines)
Cable: BASTEL Tel-Aviv
Telex: Bastel Tv 033-569

JAPAN
Yokogawa-Hewlett-Packard Ltd.
Nisei Ibaragi Bldg.
2-2-8 Kasuga
Ibaragi-Shi
Osaka
Tel: 23-1641

Yokogawa-Hewlett-Packard Ltd.
Ito Building
No. 59, Kotori-cho
Nakamura-ku, **Nagoya** City
Tel: 551-0215

Yokogawa-Hewlett-Packard Ltd.
Ohashi Building
59 Yoyogi 1-chrome
Shibuya-ku, **Tokyo**
Tel: 370-2281/7
Telex: 232-2024YHP
Cable: YHPMARKET TOK 23-724

KENYA
R. J. Tilbury Ltd.
P. O. Box 2754
Suite 517/518
Hotel Ambassadeur
Nairobi
Tel: 25670, 26803, 68206, 58196
Cable: ARJAYTEE Nairobi

KOREA
American Trading Co., Korea, Ltd.
P.O. Box 1103
Dae Kyung Bldg.
107 Sejong Ro
Chongro Ku
Seoul
Tel: 75-5841 (4 lines)
Cable: AMTRACO Seoul

LEBANON
Constantin E. Macridis
Clemenceau Street
P.O. Box 7213
Beirut
Tel: 220846
Cable: ELECTRONUCLEAR Beirut

MALAYSIA
MECOMB Malaysia Ltd.
2 Lorong 13/6A
Section 13
Petaling Jaya, **Selangor**
Cable: MECOMB Kuala Lumpur

MOZAMBIQUE
A. N. Goncalves, LDA.
4.1 Apt. 14 Av. D. Luis
P.O. Box 107
Lourenco Marques
Cable: NEGON

NEW ZEALAND
Hewlett-Packard (N.Z.) Ltd.
32-34 Kent Terrace
P.O. Box 9443
Wellington, N.Z.
Tel: 56-409
Cable: HEWPACK Wellington

PAKISTAN (EAST)
Mushko & Company, Ltd.
31, Jinnah Avenue
Dacca
Tel: 80058
Cable: NEWDEAL Dacca

PAKISTAN (WEST)
Mushko & Company, Ltd.
Oosman Chambers
Victoria Road
Karachi 3
Tel: 51027, 52927
Cable: COOPERATOR Karachi

PHILIPPINES
Electromex Inc.
2129 Pasong Tamo
Makati, Rizal
P.O. Box 4326
Manila
Tel: 88-91-71 or 88-83-76
Cable: ELEMEX Manila

SINGAPORE
Mechanical and Combustion Engineering Company Ltd.
9, Jalan Kilang
Singapore, 3
Tel: 642361-3
Cable: MECOMB Singapore

SOUTH AFRICA
Hewlett Packard South Africa (Pty.), Ltd.
Hill House
43 Somerset Rd.
Cape Town
Tel: 3-6019
Cable: HEWPACK Cape Town
Telex: 7038CT

Hewlett Packard South Africa (Pty.), Ltd.
P.O. Box 31716
30 De Beer Street
Braamfontein, **Johannesburg**
Tel: 724-4172 724-4195
Telex: 0226 JH
Cable: HEWPACK Johannesburg

TAIWAN
Hwa Sheng Electronic Co., Ltd.
P. O. Box 1558
Room 404
Chia Hsin Building
No. 96 Chung Shan North Road, Sec. 2
Taipei
Tel: 555211 Ext. 532-539
Cable: VICTRONIX Taipei

TANZANIA
R. J. Tilbury Ltd.
P.O. Box 2754
Suite 517/518
Hotel Ambassadeur
Nairobi
Tel: 25670, 26803, 68206, 58196
Telex: INTENCO BK 226
Cable: ARJAYTEE Nairobi

THAILAND
The International Engineering Co., Ltd.
P. O. Box 39
614 Sukhumvit Road
Bangkok
Tel: 910722 (7 lines)
Cable: GYSOM Bangkok

UGANDA
R. J. Tilbury Ltd.
P.O. Box 2754
Suite 517/518
Hotel Ambassadeur
Nairobi
Tel: 25670, 26803, 68206, 58196
Cable: ARJAYTEE Nairobi

VIETNAM
Peninsular Trading Inc.
P.O. Box H-3
216 Hien-Vuong
Saigon
Tel: 20.805
Cable: PENINSULA Saigon

ZAMBIA
R. J. Tilbury (Zambia) Ltd.
P.O. Box 2792
Lusaka
Zambia, Central Africa

FOR AREAS NOT LISTED, CONTACT:
Hewlett-Packard Export Marketing
3200 Hillview Ave.
Palo Alto, California 94304
Tel: (415) 326-7000
TWX: 910-373-1267
Cable: HEWPACK Palo Alto
Telex: 034-8461

MANUAL BACKDATING CHANGES

MODEL 410C

ELECTRONIC VOLTMETER

Manual Serial Prefixed: 844-
-hp- Part No. 00410-90006

This manual backdating sheet makes this manual applicable to earlier instruments. Instrument-component values that differ from those in the manual, yet are not listed in the backdating sheet, should be replaced using the part number given in the manual.

Instrument Serial Prefix	Make Manual Changes	Instrument Serial Prefix	Make Manual Changes
807- and below	1	344-	1 thru 7
550- and below	1, 2	339-	1 thru 8
550-05300 and below	1 thru 3	328-	1 thru 9
532-	1 thru 4	311-	1 thru 10
443-	1 thru 5		

CHANGE 1

Figure 5-9, Power Supply Schematic:
Add A7R7, 1100 Ω between cathode of A7CR7 and base of Q1.

Change value of A7R8 to 1200 Ω.

Section VI, Table of Replaceable Parts:
Add A7R7 R: fxd met flm 1100 Ω ±5% 1/2 W -hp- Part No. 0758-0069.

Change A7R8 to 1200 Ω -hp- Part No. 0758-0002.

CHANGE 2

Section VI, Table of Replaceable Parts:
Delete: A3C1 -hp- Part No. 0160-2641.
A3C2 -hp- Part No. 0160-3116.

Add: A3C1 -hp- Part No. 0170-0030.
A3C2 -hp- Part No. 0170-0077.

CHANGE 3

Section VI, Table of Replaceable Parts:
Delete: A3C11; Capacitor: fxd, 100 μf, 25 vdcw -hp- Part No. 0180-0094.
Add: A3C11; Capacitor: fxd, 100 μf, 50 vdcw -hp- Part No. 0180-1819.

NOTE

Later Models 410C (Serial No. 550-05301 and above use a 50 vdcw capacitor (-hp- Part No. 0180-1819) to ensure that the voltage rating of the capacitor is not exceeded. It is recommended that earlier models be modified accordingly in case of failure of the 25 vdcw capacitor.

CHANGE 4

Section VI, Table of Replaceable Parts:
Delete: C2; Capacitor: fxd, 0.1 μf -hp- Part No. 0170-0022.
Add: C2; Capacitor: fxd, 0.1 μf -hp- Part No. 0160-0001.
Add: R6; Resistor: fxd, 284 kΩ -hp- Part No. 0727-0231.

Manual Backdating Changes Model 410C Page 2

CHANGE 4 (Cont'd)

Add: R7, Resistor: fxd, 15 kΩ -hp- Part No. 0727-0168.
Add: R8; Resistor: variable, 10 kΩ -hp- Part No. 2100-1567.
Add: R9; Resistor: fxd, 25.5 kΩ -hp- Part No. 0727-0180.

Figures 3-1, 3-2, 3-3, 3-4, 3-7, 3-8:
Delete:

Figures 4-3, 4-4, 4-5, 4-6:
Delete:

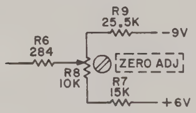
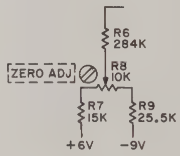


Figure 5-11, Amplifier Schematic:
Delete:



Page 5-1, Paragraph 5-11a:
Short Model 410C DCV probe to COM lead; pointèr should read zero. If not, refer to Paragraph 5-33 for adjustment procedure.

Page 5-8, Paragraph 5-34c:
Adjust A3R21 for zero meter deflection.

Page 5-8, Paragraph 5-34c:
Switch to -DCV. If any deflection is observed, adjust A3R21 to return meter pointer halfway back to zero. Check zero setting on all ranges for both +DCV and -DCV. Zero offset shall not exceed 1% in any case.

NOTE

Later Models 410C (Serial Prefix 550 and above) use the ZERO ADJUST on the rear panel for increased accuracy for DC ZERO ADJUSTMENT. It is recommended that earlier models be modified accordingly. Refer to -hp- Service Note 410C-6 for modification instructions.

CHANGE 5

Under Table of Replaceable Parts:
Delete: A3R20; Resistor, fixed, 1 kΩ; -hp- Part No. 0687-1021.
Add: A3R20; Resistor, fixed, 10 kΩ; -hp- Part No. 0686-1035.

Figure 5-10, Amplifier Schematic:
Change A3R20 from 1 kΩ to 10 kΩ.

NOTE

Later Models 410C (Serial Prefix 433 and above) use a 1 kΩ resistor for A3R20 to increase the meter zero adjustment (A3R21). It is recommended that earlier models be modified accordingly, in case of zero adjustment problem. Refer to -hp- Service Note 410C-1 for modification instructions.

CHANGE 6

Under Table of Replaceable Parts:
Delete: Q1; Transistor, PNP Germanium; -hp- Part No. 1850-0098.
Add: Q1; Transistor, PNP Germanium; -hp- Part No. 1850-0094.

CHANGE 6 (Cont'd)

NOTE

Later Models 410C (Serial Prefix 433 and above) use the -hp- Part No. 1850-0098 for increased reliability. It is recommended that earlier models be modified accordingly, in case of failure of the earlier type transistor. Refer to -hp- Service Note 410C-3 for modification instructions.

CHANGE 7

Under Table of Replaceable Parts:
Delete: CR7; Diode, Breakdown Junction, 9 V, 1.5 W; -hp- Part No. 1902-0327.
Add: A7CR7; Diode, Breakdown Junction, 9 V, 0.4 W; -hp- Part No. 1902-0037.

Figure 5-8, Power Supply Schematic:
Change CR7 to A7CR7. This designates that this diode is part of the Power Supply Assembly, A7.

NOTE

Later Models 410C (Serial Prefix 433 and above) use the 1.5 watt breakdown diode (-hp- Part No. 1902-0327) for increased reliability. It is recommended that earlier models be modified accordingly, in case of failure of the 0.4 watt diode.

CHANGE 8

Under Table of Replaceable Parts:
Delete: S3; Switch, pushbutton w/pilot light; -hp- Part No. 3101-0100.
Delete: DS1; Light, indicator, A1C neon; -hp- Part No. 1450-0106.
Delete: R5; Resistor, fixed, 68 kΩ; -hp- Part No. 0687-6831.
Add: S3; Switch, pushbutton; -hp- Part No. 3130-0054.
Add: DS1; Light, indicator, NE-2H neon; -hp- Part No. 1450-0048.
Add: Bushing, panel; -hp- Part No. 5020-0883.
Add: Actuator, AC switch; -hp- Part No. 5040-0918.
Add: Bracket; AC switch; -hp- Part No. 410C-12C.
Add: R5; Resistor, fixed, 33 kΩ; -hp- Part No. 0687-3331.

NOTE

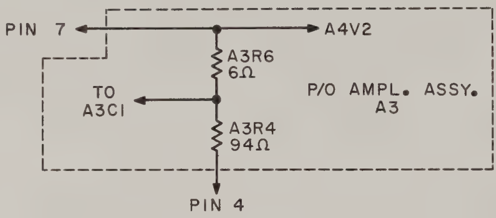
Later Models 410C (Serial Prefix 344 and above) use the -hp- Part No. 3101-0100, pushbutton switch w/pilot light for increased reliability. It is recommended that this improved switch-pilot light assembly be used for replacement, in case of failure of the older type switch. Refer to -hp-Service Note P-3101-0100 for modification instructions.

CHANGE 9

Under Table of Replaceable Parts:
Delete: A3R3; Resistor, fixed, 100 Ω; -hp- Part No. 410C-26D.
Add: A3R4; Resistor, fixed, 94 Ω; -hp- Part No. 0727-0470.
Add: A3R6; Resistor, fixed, 6 Ω; -hp- Part No. 410C-26C.

CHANGE 9 (Cont'd)

Figure 5-10, Amplifier Schematic:
Change:



CHANGE 10

Under Table of Replaceable Parts:
Delete: A1R7; Resistor, fixed, 15 kΩ; -hp- Part No. 0687-1531.
Add: A1R7; Resistor, fixed, 22 kΩ; -hp- Part No. 0758-0020.
Delete: A2R2; Resistor, fixed, 10.5 Ω; -hp- Part No. 0727-0955.
Add: A2R2; Resistor, fixed, 6 MΩ; -hp- Part No. 0727-0460.
Delete: A2R10; Resistor, fixed, 6 MΩ; -hp- Part No. 0730-0176.
Add: A2R10; Resistor, fixed, 10.8 Ω; -hp- Part No. 0728-0005.

Figure 5-13, RANGE and FUNCTION Switching (Pictorial):
Change A1R7 from 15 kΩ to 22 kΩ.
Change A2R2 from 10.5 Ω to 6 MΩ.
Change A2R10 from 6 MΩ to 10.8 Ω.

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